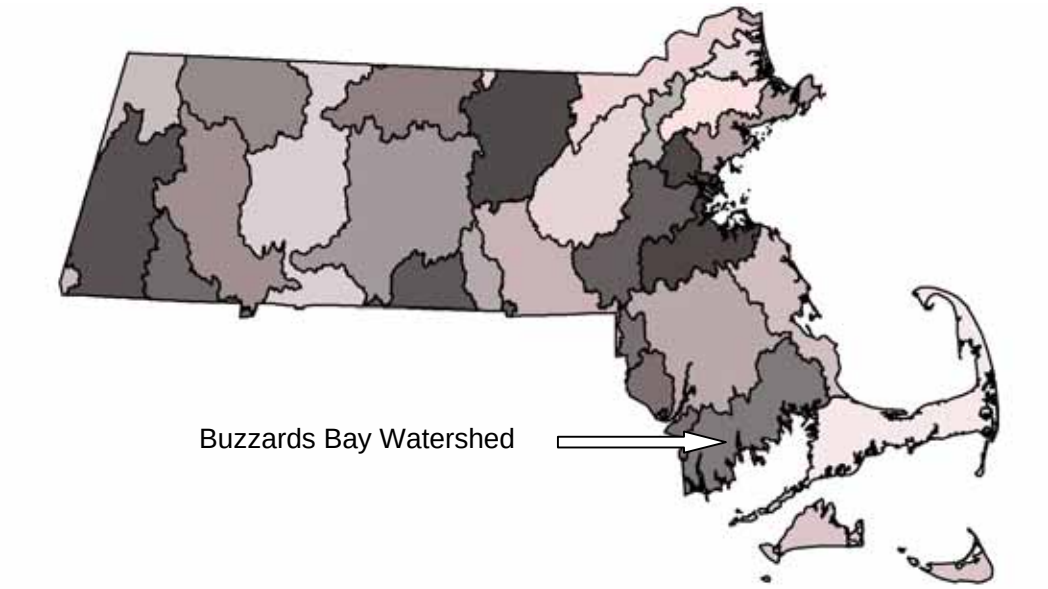
Draft Pathogen TMDL for the Buzzards Bay Watershed



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NOTICE OF AVAILABILITY

Limited copies of this report are available at no cost by written request to:

Massachusetts Department of Environmental Protection (MADEP)
Division of Watershed Management
627 Main Street
Worcester, Massachusetts 01608

This report is also available from MADEP's home page on the World Wide Web.

A complete list of reports published since 1963 is updated annually and printed in July. This list, titled "Publications of the Massachusetts Division of Watershed Management (DWM) – Watershed Planning Program, 1963-(current year)", is also available by writing to the DWM in Worcester.

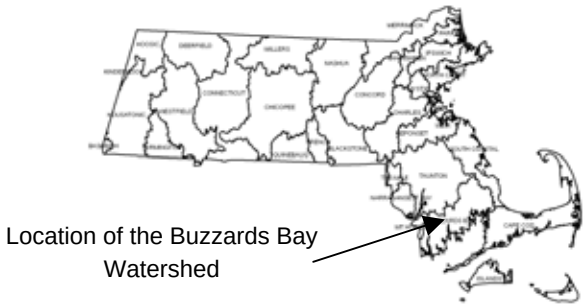
DISCLAIMER

References to trade names, commercial products, manufacturers, or distributors in this report constituted neither endorsement nor recommendations by the Division of Watershed Management for use.

Much of this document was prepared using text and general guidance from the previously approved Neponset River Basin and the Palmer River Basin Bacteria Total Maximum Daily Load documents.

Acknowledgement
This report was developed by ENSR through a partnership with Resource Triangle Institute (RTI) contracting with the United States Environmental Protection Agency (EPA) and the Massachusetts Department of Environmental Protection Agency under the National Watershed Protection Program.

Draft Total Maximum Daily Loads for Pathogens within the Buzzards Bay Watershed



Key Features: Pathogen TMDL for the Buzzards Bay Watershed

Location: EPA Region 1

Land Type: New England Coastal

303(d) Listings: Pathogens

Acushnet River (MA95-31, MA95-32, MA95-33); Agawam River (MA95-29); Apponagansett Bay (MA95-39); Aucoot Cove (MA95-09); Beaverdam Creek (MA95-53); Broad Marsh River (MA95-49); Buttermilk Bay (MA95-01); Buttonwood Brook (MA95-13); Cedar Island Creek (MA95-52); Clarks Cove (MA95-38); Crooked River (MA95-51); East Branch Westport River (MA95-40; MA95-41); Hammett Cove (MA95-56); Hiller Cove (MA95-10); Mattapoisett Harbor (MA95-35); New Bedford Inner Harbor (MA95-42); Onset Bay (MA95-02); Outer New Bedford Harbor (MA95-63); Sippican Harbor (MA95-08); Sippican River (MA95-07); Slocums River (MA95-34); Snell Creek (MA95-45); Wankinco River (MA95-50); Wareham River (MA95-03); West Branch Westport River (MA95-37); Westport River (MA95-54); Weweantic River (MA95-05).

Data Sources:

- MADEP “Buzzards Bay Watershed 2000 Water Quality Assessment Report”
- MACZM “Atlas of Stormwater Discharges in the Buzzards Bay Watershed”

Data Mechanism: Massachusetts Surface Water Quality Standards for Fecal Coliform; The Federal BEACH Act; Massachusetts Department of Public Health Bathing Beaches; Massachusetts Division of Marine Fisheries Shellfish Sanitation and Management; Massachusetts Coastal Zone Management

Monitoring Plan: Massachusetts Watershed Five-Year Cycle

Control Measures: Watershed Management; Storm Water Management (e.g., illicit discharge removals, public education/behavior modification); CSO & SSO Abatement; Agricultural and other BMPs; No Discharge Areas; By-laws; Ordinances; Septic System Maintenance/Upgrades

Executive Summary

Purpose and Intended Audience

This document provides a framework to address bacterial and other fecal-related pollution in surface waters of Massachusetts. Fecal contamination of our surface waters is most often a direct result of the improper management of human wastes, excrement from barnyard animals, pet feces and agricultural applications of manure. It can also result from large congregations of birds such as geese and gulls. Illicit discharges of boat waste are of particular concern in coastal areas. Inappropriate disposal of human and animal wastes can degrade aquatic ecosystems and negatively affect public health. Fecal contamination can also result in closures of shellfish beds, beaches, swimming holes and drinking water supplies. The closure of such important public resources can erode quality of life and diminish property values.

Who should read this document?

The following groups and individuals can benefit from the information in this report:

a) towns and municipalities, especially Phase I and Phase II storm water communities, that are required by law to address storm water and/or combined sewage overflows (CSOs) and other sources of contamination (e.g., broken sewerage pipes and illicit connections) that contribute to a waterbody's failure to meet Massachusetts Water Quality Standards for pathogens;

b) watershed groups that wish to pursue funding to identify and/or mitigate sources of pathogens in their watersheds;

c) harbormasters, public health officials and/or municipalities that are responsible for monitoring, enforcing or otherwise mitigating fecal contamination that results in beach and/or shellfish closures or results in the failure of other surface waters to meet Massachusetts standards for pathogens;

d) citizens that wish to become more aware of pollution issues and may be interested in helping build local support for funding remediation measures.

TMDL Overview

The Massachusetts Department of Environmental Protection (MADEP) is responsible for monitoring the waters of the Commonwealth, identifying those waters that are impaired, and developing a plan to bring them back into compliance with the Massachusetts Water Quality Standards (WQS). The list of impaired waters, better known as the "303d list" identifies problem lakes, coastal waters and specific segments of rivers and streams and the reason for impairment.

Once a water body is identified as impaired, the MADEP is required by the Federal Clean Water Act (CWA) to develop a "pollution budget" designed to restore the health of the impaired body of water. The process of developing this budget, generally referred to as a Total Maximum Daily Load (TMDL), includes identifying the source(s) of the pollutant from direct discharges (point sources) and indirect discharges (non-point sources), determining the maximum amount of the pollutant that can be discharged to a specific water body to meet water quality standards, and assigning pollutant load allocations to the sources. A plan to implement the necessary pollutant reductions is essential to the ultimate achievement of meeting the water quality standards.

Pathogen TMDL: This report represents a TMDL for pathogen indicators (e.g. fecal coliform, *E. coli*, and enterococcus bacteria) in the Buzzards Bay watershed. Certain bacteria, such as coliform, *E. coli*, and enterococcus bacteria, are indicators of contamination from sewage and/or the feces of warm-blooded wildlife (mammals and birds). Such contamination may pose a risk to human health. Therefore, in order to prevent further degradation in water quality and to ensure that waterbodies within the watershed meet state water quality standards, the TMDL establishes indicator bacteria limits and outlines corrective actions to achieve that goal.

Sources of indicator bacteria in the Buzzards Bay watershed were found to be many and varied. Most of the bacteria sources are believed to be storm water related. Table ES-1 provides a general compilation of likely bacteria sources in the Buzzards Bay watershed including failing septic systems, combined sewer overflows (CSO), sanitary sewer overflows (SSO), sewer pipes connected to storm drains, certain recreational activities, wildlife including birds along with domestic pets and animals and direct overland storm water runoff. Note that bacteria from wildlife would be considered a natural condition unless some form of human inducement, such as feeding, is causing congregation of wild birds or animals. A discussion of pathogen related control measures and best management practices are provided in the companion document: "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*".

This TMDL applies to the 30 pathogen impaired segments of the Buzzards Bay watershed that are currently listed on the CWA § 303(d) list of impaired waters. MADEP recommends however, that the information contained in this TMDL guide management activities for all other waters throughout the watershed to help maintain and protect existing water quality. For these non-impaired waters, Massachusetts is proposing "pollution prevention TMDLs" consistent with CWA § 303(d)(3).

The analyses conducted for the pathogen impaired segments in this TMDL would apply to the non-impaired segments, since the sources and their characteristics are equivalent. The waste load and/or load allocation for each source and designated use would be the same as specified herein. Therefore, the pollution prevention TMDLs would have identical waste load and load allocations based on the sources present and the designated use of the water body segment (see Table ES-1 and Table 6-1).

This Buzzards Bay watershed TMDL may, in appropriate circumstances, also apply to segments that are listed for pathogen impairment in subsequent Massachusetts CWA § 303(d) Integrated List of Waters. For such segments, this TMDL may apply if, after listing the waters for pathogen impairment and taking into account all relevant comments submitted on the CWA § 303(d) list, the Commonwealth determines with EPA approval of the CWA § 303(d) list that this TMDL should apply to future pathogen impaired segments.

Since accurate estimates of existing sources are generally unavailable, it is difficult to estimate the pollutant reductions for specific sources. For the illicit sources, the goal is complete elimination (100% reduction). However, overall wet weather indicator bacteria load reductions can be estimated using typical storm water bacteria concentrations. These data indicate that in general two to three orders of magnitude (i.e., greater than 90%) reductions in storm water fecal coliform loading will be necessary, especially in developed areas. This goal is expected to be accomplished through implementation of best management practices, such as those associated with the Phase II control program for storm water.

TMDL goals for each type of bacteria source are provided in Table ES-1. Municipalities are the primary responsible parties for eliminating many of these sources. TMDL implementation to achieve these goals should be an iterative process with selection and implementation of mitigation measures followed by monitoring to determine the extent of water quality improvement realized. Recommended TMDL implementation measures include identification and elimination of prohibited sources such as leaky or improperly connected sanitary sewer flows and best management practices to mitigate storm water runoff volume. Certain towns in the watershed are classified as Urban Areas by the United States Census Bureau and are subject to the Stormwater Phase II Final Rule that requires the development and implementation of an illicit discharge detection and elimination plan. Combined sewer overflows will be addressed through the on-going long-term control plans.

In most cases, authority to regulate non-point source pollution and thus successful implementation of this TMDL is limited to local government entities and will require cooperative support from local volunteers, watershed associations, and local officials in municipal government. Those activities can take the form of expanded education, obtaining and/or providing funding, and possibly local enforcement. In some cases, such as subsurface disposal of wastewater from homes, the Commonwealth provides the framework, but the administration occurs on the local level. Among federal and state funds to help implement this TMDL are, on a competitive basis, the Non-Point Source Control (CWA Section 319) Grants, Water Quality (CWA Section 604(b)) Grants, and the State Revolving (Loan) Fund Program (SRF). Most financial aid requires some local match as well. The programs mentioned are administered through the MADEP. Additional funding and resources available to assist local officials and community groups can be referenced within the Massachusetts Non-point Source Management Plan-Volume I Strategic Summary (2000) “Section VII Funding / Community Resources”. This document is available on the MADEP’s website at: www.state.ma.us/dep/brp/wm/wmpubs.htm, or by contacting the MADEP’s Nonpoint Source Program at (508) 792-7470 to request a copy.

Table ES-1. Sources and Expectations for Limiting Bacterial Contamination in the Buzzards Bay Watershed.

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)[1]	Load Allocation Indicator Bacteria (CFU/100 mL)[1]
A, B, SA, SB	Illicit discharges to storm drains	0	N/A
A, B, SA, SB	Leaking sanitary sewer lines	0	N/A
A, B, SA, SB	Failing septic systems	N/A	0
A	NPDES – WWTP	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples, nor shall 10% of the samples exceed 100 organisms[2]	N/A
A	Storm water runoff Phase I and II	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples, nor shall 10% of the samples exceed 100 organisms[3]	N/A
A	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples, nor shall 10% of the samples exceed 100 organisms[3]
B & Not Designated for Shellfishing SA & SB	CSOs	Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[4]	N/A
B & Not Designated for Shellfishing SA & SB	NPDES – WWTP	Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[2]	N/A
B & Not Designated for Shellfishing SA & SB	Storm water runoff Phase I and II	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[3]	N/A
B & Not Designated for Shellfishing SA & SB	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[3]

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)[1]	Load Allocation Indicator Bacteria (CFU/100 mL)[1]
SA Designated Shellfishing Areas	NPDES – WWTP	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms[2]	N/A
SA Designated Shellfishing Areas	Storm water Runoff Phase I and II	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms[3]	N/A
SA Designated Shellfishing Areas	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms[3]
SB Designated Shellfishing Areas	CSOs	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms[4]	N/A
SB Designated Shellfishing Areas	NPDES – WWTP	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms[2]	N/A
SB Designated Shellfishing Areas	Storm water runoff Phase I and II	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms[3]	N/A
SB Designated Shellfishing Areas	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms[3]
No Discharge Areas	Vessels – raw or treated sanitary waste	0	N/A
Marine Beaches[5]	All Sources	Enterococci not to exceed a geometric mean of 35 colonies in a statistically significant number of samples, nor shall any single sample exceed 104 colonies	Enterococci not to exceed a geometric mean of 35 colonies in a statistically significant number of samples, nor shall any single sample exceed 104 colonies

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)[1]	Load Allocation Indicator Bacteria (CFU/100 mL)[1]
Fresh Water Beaches[6]	All Sources	Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies OR *E. coli* not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies	Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies OR *E. coli* not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies

N/A means not applicable

[1] Waste Load Allocation (WLA) and Load Allocation (LA) refer to fecal coliform densities unless specified in table.

[2] Or shall be consistent with the Waste Water Treatment Plant (WWTP) National Pollutant Discharge Elimination System (NPDES) permit.

[3]The expectation for WLAs and LAs for storm water discharges is that they will be achieved through the implementation of BMPs and other controls.

[4] Or shall be consistent with an approved Long Term Control Plan (LTCP) for Combined Sewer Overflow (CSO) abatement. If the level of control specified in the LTCP is less than what is necessary to attain Class B water quality standards, then the above criteria apply unless MADEP has proposed and EPA has approved water quality standards revisions for the receiving water.

[5] Federal Beaches Environmental Assessment and Coastal Health Act of 2000 (BEACH Act) Water Quality Criteria

[6] Massachusetts Department of Public Health regulations (105 CMR Section 445)

Note: this table represents waste load and load reductions based on water quality standards current as of the publication date of these TMDLs, any future changes made to the Massachusetts water quality standards will become the governing water quality standards for these TMDLs.

Table of Contents

List of Tables

List of Figures

1.0 Introduction

Section 303(d) of the Federal Clean Water Act (CWA) and Environmental Protection Agencies (EPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to place waterbodies that do not meet established water quality standards on a list of impaired waterbodies (commonly referred to as the "303d List") and to develop Total Maximum Daily Loads (TMDLs) for listed waters and the pollutant(s) contributing to the impairment. In Massachusetts, impaired waterbodies are included in Category 5 of the "*Massachusetts Year 2002 Integrated List of Water: Part 2- Final Listing of Individual Categories of Waters*" (*2002 List*; MADEP 2003a). Figure 1-1 provides a map of the Buzzards Bay watershed with pathogen impaired segments indicated. Please note that not all segments have been assessed by the Massachusetts Department of Environmental Protection (MADEP) for pathogen impairment. As shown in Figure 1-1, much of the Buzzards Bay waterbodies are listed as a Category 5 "impaired or threatened for one or more uses and requiring a TMDL" due to excessive indicator bacteria concentrations.

TMDLs are to be developed for water bodies that are not meeting designated uses under technology-based controls only. TMDLs determine the amount of a pollutant that a waterbody can safely assimilate without violating water quality standards. The TMDL process establishes the maximum allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollutant sources and instream conditions. The TMDL process is designed to assist states and watershed stakeholders in the implementation of water quality-based controls specifically targeted to identified sources of pollution in order to restore and maintain the quality of their water resources (USEPA 1999). TMDLs allow watershed stewards to establish measurable water quality goals based on the difference between site-specific instream conditions and state water quality standards.

A major goal of this TMDL is to achieve meaningful environmental results with regard to the designated uses of the Buzzards Bay waterbodies. These include water supply, shellfish harvesting, fishing, boating, and swimming. This TMDL establishes the necessary pollutant load to achieve designated uses and water quality standard and the companion document entitled; "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*" provides guidance for the implementation of this TMDL.

Historically, water and sediment quality studies have focused on the control of point sources of pollutants (i.e., discharges from pipes and other structural conveyances) that discharge directly into well-defined hydrologic resources, such as lakes, ponds, or river segments. While this localized approach may be appropriate under certain situations, it typically fails to characterize the more subtle and chronic sources of pollutants that are widely scattered throughout a broad geographic region such as a watershed (e.g., roadway runoff, failing septic systems in high groundwater, areas of concentrated wildfowl use, fertilizers, pesticides, pet waste, and certain agricultural sources). These so called nonpoint sources of pollution often contribute significantly to the decline of water quality through their cumulative impacts. A watershed-level approach that uses the surface drainage

Figure 1-1. Buzzards Bay Watershed and Pathogen Impaired Segments

area as the basic study unit enables managers to gain a more complete understanding of the potential pollutant sources impacting a waterbody and increases the precision of identifying local problem areas or "hot spots" which may detrimentally affect water and sediment quality. It is within this watershed-level framework that the MADEP commissioned the development of watershed based TMDLs.

1.1. Pathogens and Indicator Bacteria

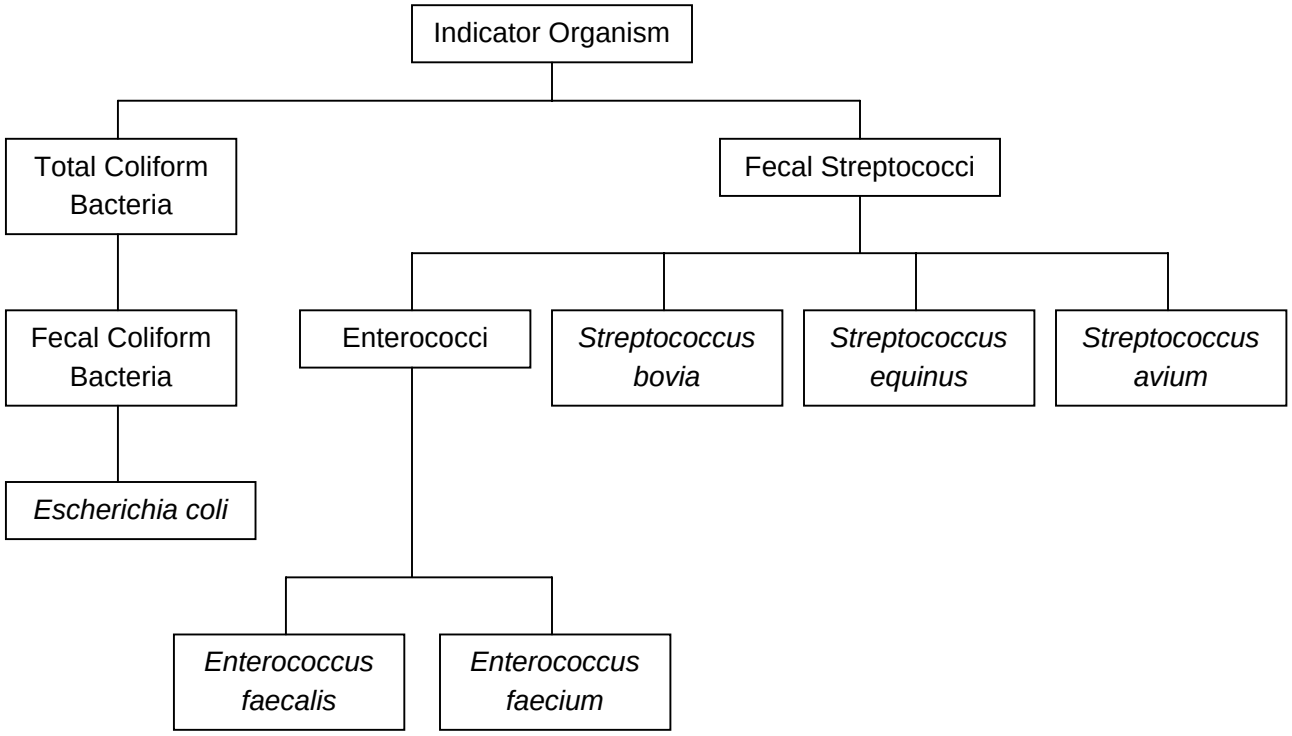
The Buzzards Bay pathogen TMDL is designed to support reduction of waterborne disease-causing organisms, known as pathogens, to reduce public health risk. Waterborne pathogens enter surface waters from a variety of sources including sewage and the feces of warm-blooded wildlife. These pathogens can pose a risk to human health due to gastrointestinal illness through exposure via ingestion and contact with recreational waters, ingestion of drinking water, and consumption of filter-feeding shellfish.

Waterborne pathogens include a broad range of bacteria and viruses that are difficult to identify and isolate. Thus, specific nonpathogenic bacteria have been identified that are typically associated with harmful pathogens in fecal contamination. These associated nonpathogenic bacteria are used as indicator bacteria as they are easier to identify and measure in the environment. High densities of indicator bacteria increase the likelihood of the presence of pathogenic organisms.

Selection of indicator bacteria is difficult as new technologies challenge current methods of detection and the strength of correlation of indicator bacteria and human illness. Currently, coliform and fecal streptococci bacteria are commonly used as indicators of potential pathogens (i.e., indicator bacteria). Coliform bacteria include total coliforms, fecal coliform and *Escherichia coli* (*E. coli*). Fecal coliform (a subset of total coliform) and *E. coli* (a subset of fecal coliform) bacteria are present in the intestinal tracts of warm blooded animals. Presence of coliform bacteria in water indicates fecal contamination and the possible presence of pathogens. Fecal streptococci bacteria are also used as indicator bacteria, specifically enterococci a subgroup of fecal streptococci. These bacteria also live in the intestinal tract of animals, but their presence is a better predictor of human gastrointestinal illness than fecal coliform since the die-off rate of enterococci is much lower (i.e., enterococci bacteria remain in the environment longer) (USEPA 2001). The relationship of indicator organisms is provided in Figure 1-2. The EPA, in the "*Ambient Water Quality Criteria for Bacteria – 1986*" document, recommends the use of *E. coli* or enterococci as potential pathogen indicators in fresh water and enterococci in marine waters (USEPA 1986).

Massachusetts uses fecal coliform and enterococci as indicator organisms of potential harmful pathogens. The WQS that apply to fresh water are currently based on fecal coliform concentration but will be replaced with *E. coli.* Fecal coliform are also used by the Massachusetts Division of Marine Fisheries (DMF) in their classification of shellfish growing areas. Fecal coliform as the indicator organism for shellfish growing area status is not expected to change at this time. Enterococci are used as the indicator organism for marine beaches, as required by the Beaches Environmental Assessment and Coastal Act of 2000 (BEACH Act), an amendment to the CWA.

Figure 1-2. Relationships among Indicator Organisms (USEPA 2001).



The Buzzards Bay watershed pathogen TMDLs have been developed using fecal coliform as an indicator bacterium for fresh and marine waters and enterococci for marine beaches. Any changes in the Massachusetts pathogen water quality standard will apply to this TMDL at the time of the standard change. Massachusetts believes that the magnitude of indicator bacteria loading reductions outlined in this TMDL will be both necessary and sufficient to attain present WQS and any future modifications to the WQS for pathogens.

1.2. Comprehensive Watershed-based Approach to TMDL Development

Consistent with Section 303(d) of the CWA, the MADEP has chosen to complete pathogen TMDLs for all waterbodies in the Buzzards Bay watershed at this time, regardless of current impairment status (i.e., for all waterbody categories in the *2002 List*). MADEP believes a comprehensive management approach carried out by all watershed communities is needed to address the ubiquitous nature of pathogen sources present in the Buzzards Bay watershed. Watershed-wide implementation is needed to meet WQS and restore designated uses in impaired segments while providing protection of desirable water quality in waters that are not currently impaired or not assessed.

As discussed below, this TMDL applies to the 30 pathogen impaired segments of the Buzzards Bay watershed that are currently listed on the CWA § 303(d) list of impaired waters and determined to be pathogen impaired in the "*Buzzards Bay Watershed 2000 Water Quality Assessment Report*" (MADEP WQA; MADEP 2003b) (see Figure 1-1, Table 4-3). MADEP recommends however, that the information contained in this TMDL guide management activities for all other waters throughout the watershed to help maintain and protect existing water quality. For these non-impaired waters, Massachusetts is proposing "pollution prevention TMDLs" consistent with CWA § 303(d)(3).

The analyses conducted for the pathogen impaired segments in this TMDL would apply to the non-impaired segments, since the sources and their characteristics are equivalent. The waste load and/or load allocation for each source and designated use would be the same as specified herein. Therefore, the pollution prevention TMDLs would have identical waste load and load allocations based on the sources present and the designated use of the water body segment (see Table ES-1 and Table 6-1).

This Buzzards Bay watershed TMDL may, in appropriate circumstances, also apply to segments that are listed for pathogen impairment in subsequent Massachusetts CWA § 303(d) Integrated List of Waters. For such segments, this TMDL may apply if, after listing the waters for pathogen impairment and taking into account all relevant comments submitted on the CWA § 303(d) list, the Commonwealth determines with EPA approval of the CWA § 303(d) list that this TMDL should apply to future pathogen impaired segments.

There are 109 waterbody segments assessed by the MADEP in the Buzzards Bay watershed (MassGIS 2005)[1]. These segments consist of 25 estuaries, all of which are pathogen impaired. Five of the 14 river segments are pathogen impaired and none of the 70 lake segments are pathogen impaired and appear as such on the official impaired waters list (303(d) List) (Figure 1-1). Pathogen impairment has been documented by the MADEP in previous reports, including the MADEP WQA, resulting in the impairment determination. In this TMDL document, an overview of pathogen impairment is provided to illustrate the nature and extent of the pathogen impairment problem. Additional data, not collected by the MADEP or used to determine impairment status, are also provided in this TMDL to illustrate the pathogen problem. Since pathogen impairment has been previously established only a summary is provided herein.

The watershed based approach applied to complete the Buzzards Bay pathogen TMDL is straightforward. The approach is focused on identification of sources, source reduction, and implementation of appropriate management plans. Once identified, sources are required to meet applicable WQS for indicator bacteria or be eliminated. This approach does not include water quality analysis or other approaches designed to link ambient concentrations with source loadings. For

[1] Some segments listed as part of the Buzzards Bay watershed in the *2002 List* are located on Cape Cod. This difference stems from basin boundary delineation differences between the *2002 List* and the WQS. This report is based on the delineation provided in the WQS. Thirteen segments listed in the *2002 List* as part of the Buzzards Bay basin not discussed in this report are provided in the "*Pathogen TMDL for the Cape Cod Watershed*".

pathogens and indicator bacteria, water quality analyses are generally resource intensive and provide results with large degrees of uncertainty. Rather, this approach focuses on sources and required load reductions, proceeding efficiently toward water quality restoration activities.

The implementation strategy for reducing indicator bacteria is an iterative process where data are gathered on an ongoing basis, sources are identified and eliminated if possible, and control measures including Best Management Practices (BMPs) are implemented, assessed and modified as needed. Measures to abate probable sources of waterborne pathogens include everything from public education, to improved storm water management, to reducing the influence from inadequate and/or failing sanitary sewer infrastructure.

1.3. TMDL Report Format

This document contains the following sections:

- Watershed Description (Section 2) - provides watershed specific information
- Water Quality Standards (Section 3) – provides a summary of current Massachusetts WQS as they relate to indicator bacteria
- Problem Assessment (Section 4) – provides an overview of indicator bacteria measurements collected in the Buzzards Bay watershed
- Identification of Sources (Section 5) – identifies and discusses potential sources of waterborne pathogens within the Buzzards Bay watershed.
- TMDL Development (Section 6) – specifies required TMDL development components including:
    - Definitions and Equation
    - Loading Capacity
    - Load and Waste Load Allocations
    - Margin of Safety
    - Seasonal Variability
- Implementation Plan (Section 7) – describes specific implementation activities designed to remove pathogen impairment. This section and the companion "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*" document should be used together to support implementing management actions.
- Monitoring Plan (Section 8) – describes recommended monitoring activities
- Reasonable Assurances (Section 9) – describes reasonable assurances the TMDL will be implemented
- Public Participation (Section 10) – describes the public participation process, and
- References (Section 11)

2.0 Watershed Description

Buzzards Bay watershed is bordered to the west by Cape Cod and to the northeast by southeastern Massachusetts. The bay is 28 miles long and 8 miles wide (MACZM 2003). The Buzzards Bay watershed drains 432 square miles and includes 17 cities and towns within Massachusetts and Rhode Island. Land use within the watershed is primarily undeveloped forest (Table 2-1, Figure 2-1). Development in the watershed is concentrated in a half mile area landward of the coastline. MADEP estimated a population of 373,690 people living in the watershed in 2000 (MADEP 2003b). Two-fifths of these people reside in the Greater New Bedford area. The 280 mile coastline includes 11 miles of public beaches (Figure 2-2). Information regarding swimming beaches can be obtained from the beach quality annual reports available for download at the Massachusetts Department of Public Health website (http://www.mass.gov/dph/beha/tox/reports/beach/beaches.htm).

The drainage basin includes several rivers, which flow into Buzzards Bay. The rivers tend to increase in velocity and width as they near the bay. In comparison to other rivers in the state, the rivers in the Buzzards Bay watershed tend to be shorter and have smaller drainage areas. Water also enters the bay through groundwater seepage.

Significant natural and cultural resources exist in the Buzzards Bay watershed that warrant special protection. The Back River and the Pocasset River have been established as Areas of Critical Environmental Concern (ACECs). Projects within ACECs are subject to state agency jurisdiction and are reviewed in greater detail to avoid deleterious impacts to these sensitive environments. The entire Buzzards Bay is considered a “No Discharge Area” (NDA). NDAs are waterbodies in which a state, with EPA approval, has determined to be important ecological or recreational areas worthy of special protection against the release of raw or treated sewage in navigable waters. Vessels are banned from discharge both raw and treated sewage in a NDA. NDAs in Massachusetts are provided in Figure 2-3 (USEPA 2004a).

The Buzzards Bay watershed waters are commonly used for primary and secondary contact recreation (swimming and boating), fishing, wildlife viewing, habitat for aquatic life, industrial cooling, shellfish harvesting, irrigation, agricultural uses, public water supply, and beachfront.

Table 2-1. Buzzards Bay Watershed Basin Land Use as of 1999.

Land Use Category	% of Total Watershed Area
Pasture	1.9
Urban Open	0.8
Open Land	3.2
Cropland	3.5
Woody Perennial	3.1
Forest	59.2
Wetland/Salt Wetland	3.8
Water Based Recreation	0.3
Water	0.3
General Undeveloped Land	76.1
Spectator Recreation	<0.1
Participation Recreation	1.3
> 1/2 acre lots Residential	7.3
1/4 - 1/2 acre lots Residential	6.0
< 1/4 acre lots Residential	2.8
Multi-family Residential	0.2
Mining	0.4
Commercial	1.8
Industrial	1.2
Transportation	1.4
Waste Disposal	1.5
General Developed Land	23.9

Figure 2-1 Buzzards Bay Watershed Land Use as of 1999.

Figure 2-2. Buzzards Bay Marine Beach Locations and Pathogen Impaired Segments.

Figure 2-3. General Location of Massachusetts' No Discharge Areas (USEPA 2004a).

3.0 Water Quality Standards

The Surface Water Quality Standards (WQS) for the Commonwealth of Massachusetts establish chemical, physical, and biological standards for the restoration and maintenance of the most sensitive uses (MADEP 2000a). The WQS limit the discharge of pollutants to surface waters for the protection of existing uses and attainment of designated uses in downstream and adjacent segments.

Fecal coliform, enterococci, and *E. coli* bacteria are found in the intestinal tract of warm-blooded animals, soil, water, and certain food and wood processing wastes. "Although they are generally not harmful themselves, they indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that also live in human and animal digestive systems" (USEPA 2004b). These bacteria are often used as indicator bacteria since it is expensive and sometimes difficult to test for the presence of individual pathogenic organisms.

Massachusetts is planning to revise its freshwater WQS by replacing fecal coliform with *E. coli* and enterococci as the regulated indicator bacteria, as recommended by the EPA in the "*Ambient Water Quality Criteria for Bacteria – 1986*" document (USEPA 1986). The state has already done so for public beaches through regulations of the Massachusetts Department of Public Health as discussed below. Currently, Massachusetts uses fecal coliform as the indicator organism for all waters except for marine bathing beaches, where the Federal BEACH Act requires the use of enterococci. Massachusetts anticipates adopting *E. coli* and enterococci for all fresh waters and enterococci for all marine waters, including non bathing marine beaches. Fecal coliform will remain the indicator organism for shellfishing areas, however. The Buzzards Bay watershed pathogen TMDL has been developed using fecal coliform as the pathogen indicator for fresh and marine waters and enterococci for marine beaches, but the goal of removing pathogen impairment of this TMDL will remain applicable when Massachusetts adopts new indicator bacteria criteria into its WQS. Massachusetts believes that the magnitude of indicator bacteria loading reductions outlined in this TMDL will be both necessary and sufficient to attain present WQS and any future modifications to the WQS for pathogens.

Pathogens can significantly impact humans through ingestion of, and contact with recreational waters, ingestion of drinking water, and consumption of filter-feeding shellfish. In addition to contact recreation, excessive pathogen numbers impact potable water supplies. The amount of treatment (i.e., disinfection) required to produce potable water increases with increased pathogen contamination. Such treatment may cause the generation of disinfection by-products that are also harmful to humans. Further detail on pathogen impacts can be accessed at the following EPA websites:

- Water Quality Criteria: Microbial (Pathogen)
  http://www.epa.gov/ost/humanhealth/microbial/microbial.html
- Human Health Advisories:
  - Fish and Wildlife Consumption Advisories
    http://www.epa.gov/ebtpages/humaadvisofishandwildlifeconsumption.html

- Swimming Advisories
  http://www.epa.gov/ebtpages/humaadvisoswimmingadvisories.html

The Buzzards Bay watershed contains waterbodies classified as Class A, Class B, Class SA, and Class SB. The corresponding WQS for each class are as follows:

> Class A waterbodies - fecal coliform bacteria shall not exceed an arithmetic mean of 20 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 100 organisms per 100 mL.
>
> Class B and Class SA and SB not designated for shellfishing - the geometric mean of a representative set of fecal coliform samples shall not exceed 200 organisms per 100 mL and no more than 10% of the samples shall exceed 400 organisms per 100 mL. The MADEP may apply these standards on a seasonal basis for waters classified as Class B, and Class SA and SB not designated for shellfishing.
>
> Class SA waters approved for open shellfishing - the geometric mean of a representative set of fecal coliform samples shall not exceed 14 organisms per 100 mL and no more than 10% of the samples shall exceed 43 organisms per 100 mL.
>
> Class SB waters approved for open shellfishing - the geometric mean of a representative set of fecal coliform samples shall not exceed 88 organisms per 100 mL and no more than 10% of the samples shall exceed 260 organisms per 100 mL.

Shellfish growing areas are classified by the Massachusetts Division of Marine Fisheries (DMF). The classification system is provided below (MassGIS 2005). Figure 1-1 provides designated shellfish growing areas status as of July 1, 2000.

> **Approved** – “Open for harvest of shellfish for direct human consumption subject to local rules and state regulations.” (MassGIS 2005) “The area is shown to be free of bacterial contaminants under a variety of climatological and hydrographical situations (i.e. assumed adverse pollution conditions).” (MADEP 2002a).
>
> **Conditionally Approved** - "During the time area is approved it is open for harvest of shellfish for direct human consumption subject to local rules and state regulations.” (MassGIS 2005) “This classification category may be assigned for growing areas subject to intermittent and predictable microbiological contamination that may be present due to operation of a sewage treatment plant, rainfall, and/or season.” (MADEP 2002a)
>
> **Conditionally Restricted** – “During the time area is restricted it is only open for the harvest of shellfish with depuration subject to local rules and state regulations.” (MassGIS 2005) “A classification used to identify a growing area that meets the criteria for the restricted classification except under certain conditions described in a management plan.” (MADEP 2002a)

Restricted – "Open for harvest of shellfish with depuration subject to local rules and state regulations or for the relay of shellfish." (MassGIS 2005) "A classification used to identify where harvesting shall be by special license and the shellstock, following harvest, is subject to a suitable and effective treatment process through relaying or depuration. Restricted growing areas are mildly or moderately contaminated only with bacteria." (MADEP 2002a)

Management Closure – "Closed for the harvest of shellfish. Not enough testing has been done in the area to determine whether it is fit for shellfish harvest or not." (MADEP 2002a)

Prohibited – "Closed for harvest of shellfish." (MassGIS 2005) "A classification used to identify a growing area where the harvest of shellstock is not permitted. Growing area waters are so badly contaminated that no reasonable amount of treatment will make the shellfish safe for human consumption. Growing areas must also be classified as Prohibited if there is no or insufficient information available to make a classification decision." (MADEP 2002a)

In general, shellfish harvesting use is supported (i.e., non-impaired) when shellfish harvested from approved open shellfish areas are suitable for consumption without depuration and shellfish harvested from restricted shellfish areas are suitable for consumption with depuration. For an expanded discussion on the relationship between the DMF shellfish growing areas classification and the MADEP designated use support status, please see the "*Buzzards Bay Watershed 2000 Water Quality Assessment Report*" (MADEP WQA; MADEP 2003b).

In addition to the WQS, the Commonwealth of Massachusetts Department of Public Health (MADPH) has established minimum standards for bathing beaches (105 CMR 445.000) under the State Sanitary Code, Chapter VII (www.mass.gov/dph/dcs/bb4_01.pdf). These standards will soon be adopted by the MADEP as state surface WQS for fresh water and these standards will subsequently apply to this TMDL. The MADPH bathing beach standards are generally the same as those which were recommended in the "*Ambient Water Quality Criteria for Bacteria – 1986"* document published by the EPA (USEPA 1986). In the above referenced document, the EPA recommended the use of enterococci as the indicator bacterium for marine recreational waters and enterococci or *E. coli* for fresh waters. As such, the following MADPH standards have been established for bathing beaches in Massachusetts:

Marine Waters - (1) No single enterococci sample shall exceed 104 colonies per 100 mL and the geometric mean of the most recent five enterococci levels within the same bathing season shall not exceed 35 colonies per 100 mL.

Freshwaters - (1) No single *E. coli* sample shall exceed 235 colonies per 100 mL and the geometric mean of the most recent five *E. coli* samples within the same bathing season shall not exceed 126 colonies per 100 mL; or (2) No single enterococci sample shall exceed 61 colonies per 100 mL and the geometric mean of the most recent five enterococci samples within the same bathing season shall not exceed 33 colonies per 100 mL.

The Federal BEACH Act of 2000 established a Federal standard for marine beaches. These standards are essentially the same as the MADPH marine beach standard (i.e., single sample not to exceed 104 cfu/100mL and geometric mean of a statistically sufficient number of samples not to exceed 35 cfu/100mL). The Federal BEACH Act and MADPH standards can be accessed on the worldwide web at http://www.epa.gov/waterscience/beaches/act.html and www.mass.gov/dph/dcs/bb4_01.pdf, respectively.

Figure 2-2 provides the location of marine bathing beaches, where the MADPH Marine Waters and the Federal BEACH Act standards would apply. A map of freshwater beaches is not available at this time. However, a list of beaches (fresh and marine) by community with indicator bacteria data can be found in the annual reports on the testing of public and semi-public beaches provided by the MADPH. These reports are available for download from the MADPH website located at http://www.mass.gov/dph/beha/tox/reports/beach/beaches.htm.

4.0 Problem Assessment

Pathogen impairment has been documented at numerous locations throughout the Buzzards Bay watershed, as shown in Figure 1-1. Excessive concentrations of indicator bacteria (e.g., fecal coliform, enterococci, *E. coli* etc.) can indicate the presence of sewage contamination and possible presence of pathogenic organisms. The amount of indicator bacteria and potential pathogens entering waterbodies is dependent on several factors including watershed characteristics and meteorological conditions. Indicator bacteria levels generally increase with increasing development activities, including increased impervious cover, illicit sewer connections, and failed septic systems.

Indicator bacteria levels also tend to increase with wet weather conditions as storm sewer systems overflow and/or storm water runoff carries fecal matter that has accumulated to the river via overland flow and storm water conduits. In some cases, dry weather bacteria concentrations can be higher when there is a constant source that becomes diluted during periods of precipitation, such as with illicit connections. The magnitude of these relationships is variable, however, and can be substantially different temporally and spatially throughout the United States or within each watershed.

Tables 4-1 and 4-2 provide ranges of fecal coliform concentrations in storm water associated with various land use types. Pristine areas are observed to have low indicator bacteria levels and residential areas are observed to have elevated indicator bacteria levels. Development activity generally leads to decreased water quality (e.g., pathogen impairment) in a watershed. Development-related watershed modification includes increased impervious surface area which can (USEPA 1997):

- Increase flow volume,
- Increase peak flow,
- Increase peak flow duration,
- Increase stream temperature,
- Decrease base flow, and
- Change sediment loading rates.

Many of the impacts associated with increased impervious surface area also result in changes in pathogen loading (e.g., increased sediment loading can result in increased pathogen loading). In addition to increased impervious surface impacts, increased human and pet densities in developed areas increase potential fecal contamination. Furthermore, storm water drainage systems and associated storm water culverts and outfall pipes often result in the channelization of streams which leads to less attenuation of pathogen pollution.

Table 4-1. Wachusett Reservoir Storm Water Sampling (as reported in MADEP 2002b) original data provided in MDC Wachusett Storm Water Study (June 1997).

Land Use Category	Fecal Coliform Bacteria[1] Organisms / 100 mL
Agriculture, Storm 1	110 – 21,200
Agriculture, Storm 2	200 – 56,400
"Pristine" (not developed, forest), Storm 1	0 – 51
"Pristine" (not developed, forest), Storm 2	8 – 766
High Density Residential (not sewered, on septic systems), Storm 1	30 – 29,600
High Density Residential (not sewered, on septic systems), Storm 2	430 – 122,000

[1] Grab samples collected for four storms between September 15, 1999 and June 7, 2000

Table 4-2. Lower Charles River Basin Storm Water Event Mean Bacteria Concentrations (data summarized from USGS 2002)[1].

Land Use Category	Fecal Coliform (CFU/100 mL)	Enterococcus Bacteria (CFU/100 mL)	Number of Events
Single Family Residential	2,800 – 94,000	5,500 – 87,000	8
Multifamily Residential	2,200 – 31,000	3,200 – 49,000	8
Commercial	680 – 28,000	2,100 – 35,000	8

[1] An Event Mean Concentration (EMC) is the concentration of a flow proportioned sample throughout a storm event. These samples are commonly collected using an automated sampler which can proportion sample aliquots based on flow.

Pathogen impaired estuary segments represent 100% of the total estuary area assessed (25 square miles). Pathogen impaired river segments represent 21.3% of the total river miles assessed (10.2 miles of 47.9 total river miles). In total, 30 segments, each in need of a TMDL, contain indicator bacteria concentrations in excess of the Massachusetts WQS for Class A, SA, B, or SB waterbodies (314 CMR 4.05)[1], the MADPH standard for bathing beaches[2], and/or the BEACH Act[3]. The basis for impairment listings is provided in the *2002 List* (MADEP 2003a). Data presented in the WQA and other data collected by the MADEP were used to generate the *2002 List*. For more information regarding the basis for listing particular segments for pathogen impairment, please see the Assessment Methodology section of the MADEP WQA for this watershed.

A list of pathogen impaired segments requiring TMDLs is provided in Table 4-3. Segments are listed and discussed in hydrologic order (upstream to downstream) in the following sections. Additional details regarding each impaired segment including water withdrawals, discharges, use assessments and recommendations to meet use criteria are provided in the MADEP WQA.

An overview of the Buzzards Bay watershed pathogen impairment is provided in this section to illustrate the nature and extent of the impairment. Since pathogen impairment has been previously established and documented on the *2002 List*, it is not necessary to provide detailed documentation of pathogen impairment herein. Data from the MADEP WQA and Massachusetts Office of Coastal Zone Management (MACZM) were reviewed and are summarized by segment below for illustrative purposes.

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[1] Class A: Fecal coliform bacteria shall not exceed an arithmetic mean of 20 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 100 organisms per 100 mL.
Class SA (Shellfishing approved): Fecal coliform bacteria shall not exceed an arithmetic mean of 14 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 43 organisms per 100 mL.
Class SB (Shellfishing approved): Fecal coliform bacteria shall not exceed an arithmetic mean of 88 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 260 organisms per 100 mL.
Class B, Class SA & Class SB (waters not designated for shellfishing): Fecal coliform bacteria shall not exceed a geometric mean of 200 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 400 organisms per 100 mL. The MADEP may apply these standards on a seasonal basis.

[2] Freshwater bathing beaches: No single *E. coli* sample shall exceed 235 colonies per 100 mL and the geometric mean of the most recent five *E. coli* samples within the same bathing season shall not exceed 126 colonies per 100 mL; or No single enterococci sample shall exceed 61 colonies per 100 mL and the geometric mean of the most recent five (5) enterococci samples within the same bathing season shall not exceed 33 colonies per 100 mL.
Marine bathing beaches: No single enterococci sample shall exceed 104 colonies per 100 mL and the geometric mean of the most recent five enterococci levels within the same bathing season shall not exceed 35 colonies per 100 mL.

[3] BEACH Act - Marine bathing beaches: No single enterococci sample shall exceed 104 colonies per 100 mL and the geometric mean of the most recent five enterococci levels within the same bathing season shall not exceed 35 colonies per 100 mL.

Table 4-3. Buzzards Bay Pathogen Impaired Segments Requiring TMDLs (adapted from MADEP 2003b and MassGIS 2005).

Segment ID	Segment Name	Segment Type	Segment Size[1]	Segment Description
MA95-40	East Branch Westport River	River	2.85	Outlet Lake Noquochoke, Westport to Old County Rd. bridge, Westport
MA95-45	Snell Creek	River	0.67	Drift Rd. to Marcus' Bridge in Westport
MA95-41	East Branch Westport River	Estuary	2.65	Old County Road bridge, Westport to the mouth at Westport Harbor, Westport (excluding Horseneck Channel)
MA95-37	West Branch Westport River	Estuary	1.28	Outlet Grays Mill Pond, Adamsville, Rhode Island to mouth at Westport Harbor, Westport
MA95-54	Westport River	Estuary	0.74	From the confluence of the East and West Branches to Rhode Island Sound; Bounded by a line drawn from the southwestern point of Horseneck Point to the easternmost point near Westport Light
MA95-34	Slocums River	Estuary	0.67	Confluence with Paskamanset R., Dartmouth to mouth at Buzzards Bay
MA95-31	Acushnet River	River	2.7	Outlet New Bedford Reservoir to Hamlin Rd. culvert, Acushnet
MA95-32	Acushnet River	River	1.0	Hamlin Rd. culvert to culvert at Main St., Acushnet
MA95-33	Acushnet River	Estuary	0.32	Main St. culvert to Coggeshall St. bridge, New Bedford/Fairhaven
MA95-42	New Bedford Harbor	Estuary	1.17	Coggeshall St. bridge to hurricane Barrier, New Bedford/Fairhaven
MA95-63	Outer New Bedford Harbor	Estuary	5.82	Hurricane Barrier to a line drawn from Wilbur Point, Fairhaven to Clarks Point, New Bedford
MA95-38	Clark Cove	Estuary	1.15	Semi-enclosed waterbody landward of a line drawn between Clarks Point, New Bedford and Ricketsons Point, Dartmouth
MA95-13	Buttonwood Brook	River	3.8	Headwaters at Oakdale St., New Bedford to mouth at Apponagansett Bay, Dartmouth
MA95-39	Apponagansett Bay	Estuary	0.95	From the mouth of Buttonwood Brook to a line drawn from Ricketsons Point, New Bedford to Samoset St. near North Ave., Dartmouth
MA95-35	Mattapoisett Harbor	Estuary	1.1	From the mouth of the Mattapoisett R., Mattapoisett, to a line drawn from Ned Point to a point of land between Bayview Avenue and Grandview Ave., Mattapoisett
MA95-56	Hammett Cove	Estuary	0.07	Hammett Cove, Marion to the confluence with Sippican Harbor along a line from the southwestern most point of Little Neck to the end of the seawall on the opposite point
MA95-08	Sippican Harbor	Estuary	2.0	From the confluence with Hammett Cove to the mouth at Buzzards Bay (excluding Blakenship Cove and Planning Island Cove), Marion
MA95-09	Aucoot Cove	Estuary	0.47	From the confluence with Aucoot Creek, Marion to the mouth at Buzzards Bay at a line drawn between Converse Point and Joes Point, Mattapoisett

Table 4-3 (continued). Buzzards Bay Pathogen Impaired Segments Requiring TMDLs (adapted from MADEP 2003b and MassGIS 2005).

Segment ID	Segment Name	Segment Type	Segment Size[1]	Segment Description
MA95-10	Hiller Cove	Estuary	0.04	Area landward of a line drawn between Joes Point, Mattapoisett and the second boat dock northeast of Hiller Cove Lane, Mattapoisett
MA95-07	Sippican River	Estuary	0.09	County Rd. to confluence with Weweantic R., Marion/Wareham
MA95-53	Beaverdam Creek	Estuary	0.04	Outlet from cranberry bogs of Rte. 6, Wareham to confluence with Weweantic River, Wareham
MA95-05	Weweantic River	Estuary	0.62	Outlet Horseshoe Pond, Wareham to mouth at Buzzards Bay, Marion/Wareham
MA95-29	Agawam River	Estuary	0.16	From the Wareham WWTP to confluence with Wankinco River at the Rte. 6 bridge, Wareham
MA95-50	Wankinco River	Estuary	0.05	Elm St. bridge, Wareham to confluence with the Agawam R., at a line between a point south of Mayflower Ridge Drive and a point north of the railroad tracks near Sandwich Rd., Wareham
MA95-49	Broad Marsh River	Estuary	0.16	From its headwaters in a salt marsh south of Marion Rd. and Bourne Terrace, Wareham to the confluence with the Wareham R.
MA95-51	Crooked River	Estuary	0.04	From the outlet of a cranberry bog, east of Indian Neck Rd., Wareham to confluence with the Wareham R., Wareham
MA95-52	Cedar Island Creek	Estuary	0.01	From the headwaters near intersection of Parker Dr. and Camardo Dr., Wareham to the mouth at Marks Cove, Wareham
MA95-03	Wareham River	Estuary	1.18	Rte. 6 bridge to mouth at Buzzards Bay (at an imaginary line from Cromset Point to curved point east, southeast of Long Beach point), Wareham. Includes Mark's Cove, Wareham
MA95-02	Onset Bay	Estuary	0.79	Wareham
MA95-01	Buttermilk Bay	Estuary	0.77	Bourne/Wareham

[1] Units = Miles for river segments and square miles for estuaries

This TMDL was based on the current WQS using fecal coliform as an indicator organism for fresh and marine waters and enteroccoci for marine beaches. Enterococci data are provided at the bottom of each table when data are available. The MADEP is in the process of developing new WQS incorporating *E. coli* and enterococci as indicator organisms for all waters other than shellfishing and potable water intake areas. Not all data presented herein were used to determine impairment listing due to a variety of reasons (including data quality assurance and quality control). The MADEP used only a subset of the available data to generate the *2002 List*. Other data presented in this section are for illustrative purposes only.

Data from the Massachusetts Division of Marine Fisheries (DMF) were used, in part, as the basis for pathogen impairment for many of the estuarine areas (Figure 1-1). Numerous samples have been collected throughout the Buzzards Bay watershed by the DMF. DMF has a well-established and effective shellfish monitoring program that provides quality assured data for each shellfish growing area. In addition, each growing area must have a complete sanitary survey every 12 years, a triennial evaluation every three years and an annual review in order to maintain a shellfishing harvesting classification with the exception of those areas already classified as Prohibited. The National Shellfish Sanitation Program establishes minimum requirements for sanitary surveys, triennial evaluations, annual reviews and annual fecal coliform water quality monitoring and includes identification of specific sources and assessment of effectiveness of controls and attainment of standards. "Each year water samples are collected by the DMF at 2,320 stations in 294 growing areas in Massachusetts's coastal waters at a minimum frequency of five times while open to harvesting" (DMF 2002). Due to the volume of data collected by the DMF, only a small sub-set of these data are provided herein. For the most recent indicator bacteria sampling data, please contact your local city or town shellfish constable or DMF's Shellfish Project.

Data summarized in the following subsections can be found at:

- **MADEP WQA 2003** – Buzzards Bay Watershed 2000 Water Quality Assessment Report available for download at http://www.mass.gov/dep/brp/wm/wqassess.htm.
- **MACZM 2003** – Atlas of Stormwater Discharges in the Buzzards Bay Watershed available for download at http://www.buzzardsbay.org/stormatlas.htm

The summary tables for each segment contain data sources and calendar years for which data were collected. The "Station" column displays the sampling location identifier issued by sampling organization and a short narrative description if available. The next three columns provide statistics relating to sampling conducted during wet and dry weather. These columns provide the number of samples collected as well as the number of those samples that were collected during the primary contact season. The next column provides the range of fecal coliform values for the samples collected at that station. The "geometric mean" column provides the geometric mean of all the samples collected for a particular station. The number and percentage of samples exceeding a threshold value is also reported in this column. The threshold values provided in this TMDL are those established by the MADEP in the WQA and are 400 cfu/100mL (Class B WQS - 10% of the samples shall not exceed 400 cfu/100mL) and 2000 cfu/100 mL (Class C WQS - 10% of the samples shall not exceed 2000 cfu/100mL). The percentage value indicates the percent of the samples exceeding the noted threshold. For example "7 samples > 400 (44%)" indicates that 7

samples contained fecal coliform densities greater than 400 cfu/100mL, equating to 44% of the samples analyzed. It should be noted that some of these percentages are calculated based on the number of samples analyzed during the primary contact season, while others may be calculated based on total number of samples.

The MADPH publishes annual reports on the testing of public and semi-public beaches for both marine and fresh waters. These documents provide water quality data for each bathing beach by community and note if there were exceedances of water quality criteria. There is also a list of communities that did not report testing results. These reports can be downloaded from http://www.mass.gov/dph/beha/tox/reports/beach/beaches.htm. Marine and freshwater beach status is highly variable and is therefore not provided in each segment description. Please see the MADPH annual beach report for specific details regarding swimming beaches.

A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of the "*Atlas of Stormwater Discharges in the Buzzards Bay Watershed*" (MACZM 2003) provided in Appendix A of this report. This map provides locations of storm drains and road cuts inventoried by the MACZM. Prioritization of these discharge points for remediation is provided in Appendix A of the "*Atlas of Stormwater Discharges in the Buzzards Bay Watershed*" (MACZM 2003) included as Appendix A in this report and is also available for download at http://www.buzzardsbay.org/stormatlas.htm.

The purpose of this section of the report is to briefly describe the impaired waterbody segments in the Buzzards Bay watershed. For more information on any of these segments, see the "*Buzzards Bay Watershed 2000 Water Quality Assessment Report*" on the MADEP website: http://www.mass.gov/dep/brp/wm/wqassess.htm.

The DMF has been regularly collecting fecal coliform data from shellfish monitoring stations (MACZM 2003). Between 1997 and 2001, DMF collected over 37,000 fecal coliform samples. The geometric means for each station sampled are summarized in Figure 14 of Appendix A in this report. The geometric means for shellfish growing areas over the same period are given in Figure 15 of Appendix A. Status of these growing areas as of July 1, 2000 is provided in Figure 1-1.

East Branch Westport River Segment MA95-40

This 2.85 mile long segment is a Class B warm water fishery in Westport. The segment begins at the outlet of Lake Noquochoke and extends to Old County Road bridge. The Dartmouth Water Department has a withdrawal point located on this segment. The East Branch Westport River watershed contains 169.4 acres of cranberry bog open space. A conservative estimate of water use by this bog area for this river segment and the upstream segment MA95-12 is 1.51 Million Gallons per Day (MGD). Mid City Scrap Iron & Salvage has a general storm water permit for this segment. The Town of Westport has submitted a Notice of Intent (NOI) requesting permit coverage under the NPDES program for their municipal separate storm sewer system (MS4). A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

A summary of fecal coliform data collected by the Westport River Watershed Alliance (WRWA) between March and October of 2001 (MADEP 2003b) is provided in Table 4-4.

Table 4-4. MA95-40 East Branch Westport River Fecal Coliform Data Summary.

Station	Total Number of Samples (Number of Samples during Primary Contact Season)	Fecal Coliform Bacteria Range (cfu/100mL)	Geometric Mean (cfu/100mL)
A-1: Westport River at Rte 177	18 (16)	2 – 2,470	83.5 3 samples > 400 (19%) 1 sample > 2,000 (5%)
3: Head of Westport River at Old Colony Rd	18 (16)	25 – 84,000	375 7 samples > 400 (44%) 4 samples > 2,000 (22%)

Enterococci counts ranged from 2-201,000 cfu/100mL (35 samples); 74% > 61 cfu/100mL

ESS conducted sampling within this segment during 2001 and 2002 (MADEP 2003b). The storm drain at Gifford Road, between Route 177 and Old Colony Road, was sampled twice and the counts were 580,000 and 2,100,000 colony forming units (cfu)/100mL. ESS suspects that this storm drain may be a significant source of bacteria during wet weather. Data for additional stations were not provided in the MADEP WQA.

Snell Creek Segment (MA95-45)

This segment 0.67 mile long Class B creek extends from Drift Road to Marcus' Bridge in Westport. The first *Concentrated Animal Feeding Operations* (CAFO) permit was issued to a farm bordering the waterbody on Drift Road. The permit requires a permanent reduction in the size of the cow herd and the use of best management practices to prevent discharges from manure and the milk parlor. The permit further requires a 100 foot vegetated buffer between pastureland and the waterbody. Town of Westport has submitted a NOI requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

A summary of fecal coliform data collected by the WRWA between March and October of 2001 (MADEP 2003b) is provided in Table 4-5.

Table 4-5. MA95-45 Snell Creek Fecal Coliform Data Summary.

Station	Total Number of Samples (Number of Samples during Primary Contact Season)	Fecal Coliform Bacteria Range (cfu/100mL)	Geometric Mean (cfu/100mL)
S-7: Snell Creek at Marcus' Bridge	17 (16)	17 – 6,000*	307.16* 7 samples > 400 (44%) 4 samples > 2,000 (24%)

* value reported as zero was not used in the number of samples analyzed, reported range or calculation.

Enterococci counts ranged from 12-94,000 cfu/100mL

East Branch Westport River Segment (MA95-41)

This Class SB Shellfishing (restricted) segment covers 2.65 square miles beginning at Old County Road bridge. In the East Branch Westport River subwatershed, cranberry bogs make up 169.4 acres of open space and use an estimated 1.51 MGD (including water use for the upstream segments MA95-40 and MA95-45). F L Tripp & Sons Inc. has a general storm water permit to discharge in this watershed. This river segment is adjacent to a farm on Drift Road, which was issued the CAFO permit as discussed under Snell Creek MA95-45. Town of Westport has submitted a NOI requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Shellfish harvesting is impaired because of elevated levels of fecal coliform in 0.64 square miles of this segment. Designated shellfish growing areas status as of July 1, 2000 is provided in Figure 1-1. Summaries of fecal coliform data are provided in Figures 14 and 15 of Appendix A.

A summary of fecal coliform data collected by the WRWA between March and October of 2001 and data collected by ESS (MADEP 2003b) are provided in Tables 4-6 and 4-7.

Table 4-6. MA95-41 East Branch Westport River WRWA Fecal Coliform Data Summary.

Station	Total Number of Samples (Number of Samples during Primary Contact Season)	Fecal Coliform Bacteria Range (cfu/100mL)	Geometric Mean (cfu/100mL)
14	23 (20)	2 - 2,900	30.56 3 samples > 400 (14%) 1 sample > 2,000 (4%)
15	20 (18)	1 - 9,200	30.54 4 samples > 400 (22%) 3 samples > 2,000 (15%)
17	15 (14)	6 - 25,000	89.70 4 samples > 400 (29%) 2 samples > 2,000 (13%)
18	15 (13)	6 - 30,600	321.93 4 samples > 2000 (27%)
19	15 (15)	10 - 29,900	291.71 4 samples > 2,000 (27%)
KB	11 (10)	56 - 31,800	422.85 2 samples > 2,000 (18%)
K4	20 (18)	14 - 2,500	87.02 2 samples > 400 (11%) 1 sample > 2,000 (5%)

Enterococci counts ranged from 0-49,400 cfu/100mL (83 samples)

Table 4-7. MA95-41 East Branch Westport River ESS Fecal Coliform Data (MADEP 2003b).

Station	Number of Samples	Fecal Coliform Bacteria Range (cfu/100mL)
WR1: downstream of Head Bridge/Old Colony Road	3	1 - 700
WR2: east side of Head Bridge at Old Colony Rd.	2	610 - 1,600
WR5: Gifford Road (located upstream of this segment in MA95-40)	2	580,000 - 2,100,000

West Branch Westport River Segment MA95-37

This 1.28 square mile segment begins at the outlet of Gray's Mill Pond (also known as Adamsville Pond) in Adamsville, Rhode Island to the mouth at Westport Harbor in Westport. This segment is a Class SA, shellfishing (open) waterbody. The Gray's Mill Pond, which is created by a dam and is used by Gray's Grist Mill forms the headwaters of this segment. There are no permitted NPDES dischargers in this segment. Town of Westport has submitted a NOI requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Shellfish harvesting is impaired in 0.78 square miles of this segment. The suspected source of fecal coliform is the MS4. Designated shellfish growing areas status as of July 1, 2000 is provided in Figure 1-1. Summaries of fecal coliform data are provided in Figures 14 and 15 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

A summary of fecal coliform data collected by WRWA between March and October 2001 (MADEP 2003b) is provided in Table 4-8.

Table 4-8. MA95-37 West Branch Westport River Fecal Coliform Data Summary.

Station	Total Number of Samples (Number of Samples during Primary Contact Season)	Fecal Coliform Bacteria Range (cfu/100mL)	Geometric Mean*
6: in river near 448 River Road	19 (17)	0 - 2,500	8.6 1 sample > 400 (6%)

* zero value reported in the range was not used in the calculation
Enterococci counts ranged from 0-3,200 cfu/100mL

Westport River MA95-54

This 0.74 square mile segment is a Class SA waterbody. The segment extends from the confluences of the East and West Branches of the Westport River to Rhode Island Sound. The Town of Westport has submitted a NOI requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Shellfish harvesting is supported in 0.5 square miles of this segment and impaired in 0.78 square miles due to elevated fecal coliform concentrations. Designated shellfish growing areas status as of July 1, 2000 is provided in Figure 1-1. Summaries of fecal coliform data are provided in Figures 14 and 15 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

A summary of fecal coliform data collected by WRWA between March and October 2001 (MADEP 2003b) is provided in Table 4-9.

Table 4-9. MA95-54 Westport River Fecal Coliform Data Summary.

Station	Total Number of Samples (Number of Samples during Primary Contact Season)	Fecal Coliform Bacteria Range (cfu/100mL)	Geometric Mean (cfu/100mL)
11A: Off of Westport Town Wharf	19 (17)	<1 - 1040	5.02 1 sample > 400 (6%)
7: Harbor entrance at Charlton Wharf	9* (9)	1 - 157	5.93

* value reported as zero was not used in the reported range or calculation

Enterococci counts for 11A ranged from 0-410 cfu/100mL (17 samples); counts at station 7 ranged from 0-240 (17 samples)

Slocums River Segment MA95-34

This 0.67 square mile segment is a Class SA, Shellfishing (open) waterbody. The segment begins at the confluence with Paskamanset River at Rock O'Dundee Road in Dartmouth and flows to its mouth at Buzzards Bay in Dartmouth. The Slocums River subwatershed contains 74.6 acres of cranberry bog open space. A conservative estimate of the bogs' water use (including the upstream segment MA95-11) is 0.41 MGD. The discharges from general permittees into the Paskamansett River, an upstream segment, ultimately end up in this segment. Discharge permits on the Paskamansett River include nine general storm water permits and one permit to discharge emergency overflow from lagoons at the Chase Road Well D Water Treatment Plant. The Town of Dartmouth has submitted a NOI requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Impairment status for this segment was based on DMF data. Shellfish harvesting is supported in 0.01 square miles and impaired in 0.66 square miles of this segment. Designated shellfish growing areas status as of July 1, 2000 is provided in Figure 1-1. Summaries of fecal coliform data are provided in Figures 14 and 15 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Acushnet River Segment MA95-31

This 2.7 mile long Class B warm water fishery flows from the outlet of the New Bedford Reservoir to the Hamlin Road culvert in Acushnet. The Acushnet River Golf Course has an irrigation well, which withdraws an average 0.1 MGD. The subwatershed contains 423.7 acres of cranberry bog open space. A conservative estimate of water use by the bogs is 3.78 MGD. The Town of Acushnet has

submitted a NOI requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Acushnet River Segment MA95-32

This 1.10 mile long Class B warm water fishery flows from the Hamlin Road culvert to the culvert at Main Street, both in Acushnet. The Division of Marine Fisheries (DMF) has completed Environmental Notification Forms (ENF) for a project to remove the Saw Mill Dam and the dam at Hamlin Street, both located along this segment. The Acushnet River subwatershed contains 429.6 acres of cranberry bog open space. A conservative estimate of water use by the bogs is 3.84 MGD (estimate includes water use for upstream segment MA95-31). The only NPDES permitted discharger along this segment is the Acushnet Company-Titleist Golf Division. The company discharges treated sanitary waster (via outfall 008) and treated process waste, NCCW, and boiler blow-down (via outfall 010). The outfall's secondary limit for fecal coliform bacteria is 200/100mL. The Town of Acushnet has submitted a NOI requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Acushnet River Segment MA95-33

This 0.31 square mile segment is a Class SB, Shellfishing (Restricted), CSO river segment. The segment runs from the outlet Main Street culvert in Acushnet to the Coggeshall Street bridge in New Bedford/Fairhaven. The Acushnet River subwatershed contains 429.602 acres of cranberry bog open space. A conservative estimate of water use by the bogs is 3.84 MGD (estimate includes water use for upstream segment MA95-32). This segment receives discharges from ten CSOs in the City of New Bedford. This segment also receives discharge from nine storm drains. Aerovox Inc. has a permit to discharge storm water into the Acushnet River/New Bedford Harbor. Additionally, Riverside Auto Service, Titleist and Foot Joy Ball Planting, and Acushnet Rubber Company have general storm water permits. The towns of Acushnet, Fairhaven, and New Bedford have submitted NOIs requesting permit coverage under the NPDES program for their MS4s. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Impairment status for this segment was based on DMF data. This segment is impaired for shellfish harvesting. The causes of impairment are elevated fecal coliform concentrations and PCBs. Designated shellfish growing areas status as of July 1, 2000 is provided in Figure 1-1. Summaries of fecal coliform data are provided in Figures 14 and 15 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

New Bedford Inner Harbor Segment MA95-42

This 1.25 square mile segment is a Class SB Shellfishing (restricted), CSO area. The segment extends from Coggeshall Street Bridge to Hurricane Barrier in New Bedford/Fairhaven. In the 1960s the New Bedford-Fairhaven-Acushnet Hurricane Protection Project made three major alterations to the Harbor: a barrier across New Bedford and Fairhaven Harbor including an extension dike on the mainland, Clarks Cove Dike, and Fairhaven Dike. The New Bedford Inner Harbor subwatershed

contains 429.6 acres of cranberry bog open space. A conservative estimate of water use by the bogs is 3.84 MGD (estimate includes upstream segment MA95-33). Revere Copper Products, Inc. withdraws water from this river segment.

Industrial waste water NPDES permittees include Revere Copper Products, Inc. (three outfalls), Glen Petroleum Company, and Trio Agarvio Inc. NPDES storm water dischargers include Revere Copper Products, Inc. (two outfalls), DN Kelley & Son Inc. and Global Companies LLC. The City of Bedford (12 CSOs and 6 storm water outfalls) and the Town of Fairhaven have submitted NOIs for NPDES MS4 coverage. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A. Sanitary waste NPDES dischargers include the Town of Fairhaven and the City of Bedford (12 CSO outfalls) into the Acushnet River.

Impairment status for this segment was based on DMF data. Shellfish harvesting is impaired in this segment due to fecal coliform bacteria and PCBs. Designated shellfish growing areas status as of July 1, 2000 is provided in Figure 1-1. Summaries of fecal coliform data are provided in Figures 14 and 15 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Outer New Bedford Harbor Segment MA95-63

This 5.82 square mile segment is a Class SA, Shellfishing (open) segment. The outer harbor is defined by a straight line connecting Wilbur Point to Clarks Point and extends inwards to the Hurricane Barrier. The New Bedford Inner Harbor subwatershed contains 429.6 acres of cranberry bog open space. A conservative estimate of water use by the bogs is 3.84 MGD (estimate includes upstream segments MA95-38 and MA95-42). Seven CSOs in the City of New Bedford discharge into the outer harbor. The city is also permitted to discharge storm water into Clark's Cove and Outer New Bedford Harbor. Cornell-Dubilier Electronics Corporation discharges storm water to Fort Phoenix Reach near the Acushnet River Estuary in the Lower harbor. Allegheny Rodney also has a storm water permit to discharge in this segment. Fairhaven and New Bedford have submitted NOI s requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Impairment status for this segment was based on DMF data. Shellfish harvesting in this segment is impaired due to fecal coliform bacteria. Designated shellfish growing areas status as of July 1, 2000 is provided in Figure 1-1. Summaries of fecal coliform data are provided in Figures 14 and 15 of Appendix A.

Clarks Cove Segment MA95-38

This segment is a 1.90 square mile Class SA Shellfishing (open) combined sewer overflow (CSO) receiving water body. The cove extends from Clarks Point in New Bedford southeast to Ricketsons Point in Dartmouth. New Bedford discharges site dewatering discharges and storm water into Clark's Cove. New Bedford also discharges via nine CSOs. Dartmouth and New Bedford have submitted NOIs requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Impairment status for this segment was based on DMF data. Shellfish harvesting in this segment is impaired by fecal coliform. Designated shellfish growing areas status as of July 1, 2000 is provided in Figure 1-1. Summaries of fecal coliform data are provided in Figures 14 and 15 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Buttonwood Brook Segment MA95-13

This 3.8 mile long, Class B segment begins at its headwaters at Oakdale Street in New Bedford and flows to its mouth at Apponagansett Bay in Dartmouth. Buttonwood Brook has been engineered for storm water management and is considered a "controlled stream." Buttonwood Brook is the major source of fecal coliform to Apponagansett Bay. Dartmouth and New Bedford have submitted NOIs requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Apponagansett Bay Segment MA95-39

This is a 0.95 square mile Class SA Shellfishing (open) waterbody. Apponagansett Bay begins at the mouth of Buttonwood Brook and stretches to Ricketsons Point in New Bedford and Samoset Street in Dartmouth. The Apponagansett Bay subwatershed contains 4. 5 acres of cranberry bog open space. A conservative estimate of water use by the bogs is 0.04 MGD. Davis and Tripp Inc. is permitted to discharge within this segment. Dartmouth has submitted an NOI requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Impairment status for this segment was based on DMF data. High concentrations of fecal coliform have caused 0.68 square miles of the Bay to be impaired for shellfish harvesting. Designated shellfish growing areas status as of July 1, 2000 is provided in Figure 1-1. Summaries of fecal coliform data are provided in Figures 14 and 15 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Mattapoisett Harbor Segment MA95-35

This is a 1.10 square mile Class SA, Shellfishing (open) segment. The segment begins at the mouth of the Mattapoisett River and extends to Ned Point and to a point of land between Bayview and Grandview Avenues in Mattapoisett. The Fairhaven Water Department has one withdrawal point on this segment. Coen Brook is a tributary to Mattapoisett Harbor. The Old Rochester Regional School District has a permit to discharge treated sewage effluent into Coen Brook. In 2002, the school district tied into the Mattapoisett sewer system, which, after going through the Fairhaven WWTF, discharges treated water into the New Bedford Inner Harbor. Mattapoisett has submitted an NOI requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Impairment status for this segment was based on DMF data. Shellfish harvesting in this segment is supported for 1.0 square miles and is impaired for 0.1 square miles due to excessive fecal coliform.

Designated shellfish growing areas status as of July 1, 2000 is provided in Figure 1-1. Summaries of fecal coliform data are provided in Figures 14 and 15 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Hammett Cove Segment MA95-56

This is a 0.07 square mile Class SA waterbody. Hammett Cove is located in Marion and runs south to the confluence with Sippican Harbor. A line connecting the southwest most point of Little Neck to the end of the seawall on the opposite point delineates the southern boundary of this segment. The Hammett Cove subwatershed contains 34.7 acres of cranberry bog open space. A conservative estimate of water use by the bogs is 0.31 MGD. Marion has submitted an NOI requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Impairment status for this segment was based on DMF data. Shellfish harvesting is impaired in 0.02 square miles of this segment due to elevated fecal coliform. Designated shellfish growing areas status as of July 1, 2000 is provided in Figure 1-1. Summaries of fecal coliform data are provided in Figures 14 and 15 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Sippican Harbor Segment MA95-08

This is a 2.0 square mile Class SA Shellfishing (open) waterbody. Sippican Harbor extends from the confluence with Hammetts Cove to the mouth of Buzzards Bay (excluding Blankenship Cove and Planning Island Cove). The Sippican Harbor subwatershed contains 37.8 acres of cranberry bog open space. A conservative estimate of water use by the bogs is 0.34 MGD. Barden's Boat Yard Inc and Edey & Duff Ltd. have general storm water permits. Marion has submitted an NOI requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm. Island Wharf has a vessel sewage pumpout shoreside facility and porta-potty dump.

Impairment status for this segment was based on DMF data. Shellfish harvesting is impaired in 0.30 square miles of this segment due to fecal coliform. Designated shellfish growing areas status as of July 1, 2000 is provided in Figure 1-1. Summaries of fecal coliform data are provided in Figures 14 and 15 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Aucoot Cove Segment MA95-09

This is a 0.50 square mile Class SA, Shellfishing (open) segment. Aucoot Cove extends from the confluence with Aucoot Creek to the mouth of Buzzards Bay. The area is bounded to the south by a line drawn from Converse Point to Joes Point. The Aucoot Cove subwatershed contains 52.7 acres of cranberry bog open space. A conservative estimate of water use by the bogs is 0.47 MGD. Marion is has submitted an NOI requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm. The Town of

Marion Waste Water Treatment Plant discharges treated waste water into an unnamed brook tributary to Aucoot Cove.

Impairment status for this segment was based on DMF data. Shellfish harvesting is impaired in 0.04 square miles of this segment. Designated shellfish growing areas status as of July 1, 2000 is provided in Figure 1-1. Summaries of fecal coliform data are provided in Figures 14 and 15 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Hiller Cove Segment MA95-10

This 0.04 square mile Class SA segment is located landward of a line drawn between Jones Point and the second boat dock northeast of Hiller Cove Lane in Mattapoisett. Mattapoisett has submitted an NOI requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Impairment status for this segment was based on DMF data. Shellfish harvesting is impaired in 0.01 square miles of Hiller Cove due to excessive fecal coliform numbers. Designated shellfish growing areas status as of July 1, 2000 is provided in Figure 1-1. Summaries of fecal coliform data are provided in Figures 14 and 15 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Sippican River Segment MA95-07

This 0.08 square mile segment is a Class SA, Shellfishing (open) river segment. This segment flows from County Road to its confluence with Weweantic River in Marion/Wareham. The Sippican River subwatershed contains 2313.1 acres of cranberry bog open space. A conservative estimate of water use by the bogs in this segment is 2.88 MGD. Marrion has submitted an NOI requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Impairment status for this segment was based on DMF data. This entire river segment is impaired for shellfishing due to excessive fecal coliform numbers. Designated shellfish growing areas status as of July 1, 2000 is provided in Figure 1-1. Summaries of fecal coliform data are provided in Figures 14 and 15 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Beaverdam Creek Segment MA95-53

This is a 0.04 square mile Class SA segment. Beaverdam Creek begins at the outlet from the cranberry bogs southeast of Route 6 and flows to its confluence with the Weweantic River. The Beaverdam Creek subwatershed contains 40.8 acres of cranberry bog open space. A conservative estimate of water use by the bogs in this segment is 0.36 MGD. Wareham has submitted an NOI requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Impairment status for this segment was based on DMF data. Excessive fecal coliform numbers have caused shellfish harvesting impairment in this segment. Designated shellfish growing areas status as of July 1, 2000 is provided in Figure 1-1. Summaries of fecal coliform data are provided in Figures 14 and 15 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Weweantic River Segment MA95-05

This is a 0.62 square mile Class SA, Shellfishing (open) segment. The segment begins at the outlet to Horseshoe Pond in Wareham and continues to the mouth at Buzzards Bay in Marion/Wareham. Point Independence Yacht Club has a vessel sewage pumpout sewage facility within this segment. SEMASS Partnership has three industrial wells along this segment. The Weweantic River subwatershed contains 8969.4 acres of cranberry bog open space. A conservative estimate of water use by the bogs is 80.09 MGD (estimate includes segments MA95-04 and MA95-07). Wareham, Marion, and Rochester have submitted NOIs requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Impairment status for this segment was based on DMF data. Excessive fecal coliform numbers have caused shellfish harvesting impairment in 0.45 square miles of this segment. MADEP suspects municipal separate storm sewer systems and septic systems to be the source of bacteria. Designated shellfish growing areas status as of July 1, 2000 is provided in Figure 1-1. Summaries of fecal coliform data are provided in Figures 14 and 15 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Agawam River Segment MA95-29

This 0.16 mile long segment is a Class SB Shellfishing restricted river segment. The segment runs from the Wareham WWTP to the confluence with Wankinco River at the Route 6 bridge in Wareham. The Wareham Fire District has two withdrawal points. The Agawam River subwatershed contains 2792.0 acres of cranberry bog open space. A conservative estimate of water use by the bogs is 24.93 MGD (estimate includes segments MA95-28 and MA95-30). The Town of Wareham has a permit to discharge treated sanitary wastewater into the Agawam River. Wareham has submitted an NOI requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Impairment status for this segment was based on DMF data. Shellfish harvesting along this segment is impaired due to excessive fecal coliform numbers. Designated shellfish growing areas status as of July 1, 2000 is provided in Figure 1-1. Summaries of fecal coliform data are provided in Figures 14 and 15 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Wankinco River Segment MA95-50

This 0.05 square mile Class SA waterbody extends from the Elm Street bridge in Wareham to the confluence with the Agawam River. The subwatershed of the upstream segment MA95-30 contains 1770.6 acres of cranberry bog open space. Wareham has submitted an NOI requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Impairment status for this segment was based on DMF data. Shellfish harvesting along this segment is impaired due to excessive fecal coliform numbers. Designated shellfish growing areas status as of July 1, 2000 is provided in Figure 1-1. Summaries of fecal coliform data are provided in Figures 14 and 15 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Broad Marsh River Segment MA95-49

This 0.16 square mile Class SA waterbody flows from its headwaters in a salt marsh south of Marion Road to the confluence with the Wareham River. There is a public beach as well as several private beaches along the river. Wareham has submitted an NOI requesting permit coverage under the NPDES program for their MS4. Fifteen storm drain pipes discharge directly into the river. The Broad Marsh Stormwater Remediation Project reduced fecal coliform numbers in runoff by >99.99%, according to post-project monitoring (MADEP 2003b). A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Impairment status for this segment was based on DMF data. Shellfish harvesting along this segment is impaired due to excessive fecal coliform numbers. Designated shellfish growing areas status as of July 1, 2000 is provided in Figure 1-1. Summaries of fecal coliform data are provided in Figures 14 and 15 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Crooked River Segment MA95-51

This 0.04 square mile Class SA waterbody extends from the outlet of a cranberry bog, east of Indian Neck Road, to the confluence with Wareham River. Wareham has submitted an NOI requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Impairment status for this segment was based on DMF data. Shellfish harvesting along this segment is impaired due to excessive fecal coliform numbers. Designated shellfish growing areas status as of July 1, 2000 is provided in Figure 1-1. Summaries of fecal coliform data are provided in Figures 14 and 15 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Cedar Island Creek Segment MA95-52

This 0.01 square mile Class SA waterbody extends from the headwaters near the intersection of Parker Drive and Camardo Drive to the mouth at Marks Cove. Wareham has submitted an NOI requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Impairment status for this segment was based on DMF data. Shellfish harvesting along this segment is impaired due to excessive fecal coliform numbers. Designated shellfish growing areas status as of July 1, 2000 is provided in Figure 1-1. Summaries of fecal coliform data are provided in Figures 14 and 15 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Wareham River Segment MA95-03

This 1.18 square mile Class SA Shellfishing (open) river segment extends from the Route 6 bridge to the mouth at Buzzards Bay. Warr's Marine has a vessel pump-out facility and porta-potty dump located within this segment. The Wareham River subwatershed contains 2842.5 acres of cranberry bog open space. A conservative estimate of water use by the bogs contained in this segment is 0.45 MGD. Wareham has submitted an NOI requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Impairment status for this segment was based on DMF data. Shellfish harvesting is impaired in 0.25 square miles of this segment due to excessive fecal coliform numbers. Designated shellfish growing areas status as of July 1, 2000 is provided in Figure 1-1. Summaries of fecal coliform data are provided in Figures 14 and 15 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Onset Bay Segment MA95-02

This 0.78 square mile Class SA segment is located in Wareham. Three vessel sewage pumpout facilities are located on this segment. The Onset Fire District has two withdrawal points in this segment. The Onset Bay subwatershed contains 162.8 acres of cranberry bog open space. A conservative estimate of water use by the bogs in this area is 1.45 MGD. Wareham has submitted an NOI requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Impairment status for this segment was based on DMF data. Shellfish harvesting is impaired in 0.15 square miles of this segment due to excessive fecal coliform numbers. Designated shellfish growing areas status as of July 1, 2000 is provided in Figure 1-1. Summaries of fecal coliform data are provided in Figures 14 and 15 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Buttermilk Bay Segment MA95-01

This 0.67 square mile Class SA segment is located in Bourne/Wareham. There is one vessel sewage pump-out boat in this segment. The Atlantic Country Club, Buzzards Bay Water District, Bourne, Plymouth Water Company, Plymouth, and the Onset Fire District all withdraw water from the bay. The Buttermilk Bay subwatershed contains 515.0 acres of cranberry bog open space. A conservative estimate of water use by the bogs in this segment is 4.60 MGD. Bourne and Wareham have submitted NOIs requesting permit coverage under the NPDES program for their MS4. A map of storm water discharges within the Buzzards Bay basin is provided in Figure 19 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

Impairment status for this segment was based on DMF data. Shellfish harvesting is impaired in 0.16 square miles of this segment due to excessive fecal coliform numbers. Designated shellfish growing areas status as of July 1, 2000 is provided in Figure 1-1. Summaries of fecal coliform data are provided in Figures 14 and 15 of Appendix A; also available for download at http://www.buzzardsbay.org/stormatlas.htm.

5.0 Potential Sources

The Buzzards Bay watershed has 30 segments, located throughout the watershed, that are listed as pathogen impaired requiring a TMDL. These segments represent 100% of the estuary area and 21.3% of the river miles assessed. Sources of indicator bacteria in the Buzzards Bay watershed are many and varied. A significant amount of work has been done in the last decade to improve the water quality in the Buzzards Bay watershed.

Largely through the efforts of the WRWA, the DMF, MACZM, and MADEP field staff, numerous point and non-point sources of pathogens have been identified. Table 5-1 summarizes the river segments impaired due to measured indicator bacteria densities and identifies some of the suspected and known sources identified in the WQA or by other organizations (e.g., MACZM, WRWA, etc.).

Some dry weather sources include:

- animal feeding operations,
- animal grazing in riparian zones,
- leaking sewer pipes,
- storm water drainage systems (illicit connections of sanitary sewers to storm drains),
- failing septic systems,
- recreational activities,
- wildlife, including birds, and
- illicit boat discharges.

Some wet weather sources include:

- wildlife and domesticated animals (including pets),
- storm water runoff including municipal separate storm sewer systems (MS4),
- combined sewer overflows (CSOs), and
- sanitary sewer overflows (SSOs).

It is difficult to provide accurate quantitative estimates of indicator bacteria contributions from the various sources in the Buzzards Bay watershed because many of the sources are diffuse and intermittent, and extremely difficult to monitor or accurately model. Therefore, a general level of quantification according to source category is provided (e.g., see Tables 5-2 and 5-3). This approach is suitable for the TMDL analysis because it indicates the magnitude of the sources and illustrates the need for controlling them. Additionally, many of the sources (failing septic systems, leaking sewer pipes, sanitary sewer overflows, and illicit sanitary sewer connections) are prohibited, because they indicate a potential health risk and, therefore, must be eliminated. However, estimating the magnitude of overall indicator bacteria loading (the sum of all contributing sources) is achieved for wet and dry conditions using the extensive ambient data available that define baseline conditions (see segment summary tables, Appendix A, and MADEP 2003b).

Table 5-1. Some of the Potential Sources of Bacteria in Pathogen Impaired Segments in the Buzzards Bay Watershed.

Segment	Segment Name	Potential Sources
MA95-40	East Branch Westport River	MS4, highway/road runoff, animal feeding operations
MA95-45	Snell Creek	MS4, on-site septic systems, highway/road runoff
MA95-41	East Branch Westport River	Animal feeding operation, dairy outside milk parlor area, grazing in riparian zone, MS4, on-site septic systems, highway/road runoff
MA95-37	West Branch Westport River	MS4
MA95-54	Westport River	MS4
MA95-34	Slocums River	On-site treatment systems (septic systems), urbanized high density area, MS4
MA95-31	Acushnet River	Unknown
MA95-32	Acushnet River	Unknown
MA95-33	Acushnet River	CSO, urbanized high density area
MA95-42	New Bedford Inner Harbor	CSO, urbanized high density area, waterfowl
MA95-63	Outer New Bedford Harbor	MS4
MA95-38	Clarks Cove	CSO, urbanized high density area, MS4
MA95-13	Buttonwood Brook	Unknown
MA95-39	Apponagansett Bay	On-site treatment systems, urbanized high density area, MS4
MA95-35	Mattapoisett Harbor	MS4
MA95-56	Hammett Cove	MS4
MA95-08	Sippican Harbor	MS4
MA95-09	Aucoot Cove	MS4
MA95-10	Hiller Cove	MS4
MA95-07	Sippican River	MS4
MA95-53	Beaverdam Creek	MS4
MA95-05	Weweantic River	MS4, on-site treatment systems (septic systems)
MA95-29	Agawam River	MS4, municipal point source discharge
MA95-50	Wankinco River	MS4
MA95-49	Broad Marsh River	MS4
MA95-51	Crooked River	MS4
MA95-52	Cedar Island Creek	MS4
MA95-03	Wareham River	MS4
MA95-02	Onset Bay	MS4
MA95-01	Buttermilk Bay	MS4

MS4 = Municipal Separate Storm Water Sewer System – community storm water drainage system

Most sources were identified in the MADEP WQA, although some sources have been identified by other organizations such as WRWA and MACZM.

Agriculture – Animal Feeding Operations and Grazing

Land used primarily for agriculture is likely to be impacted by a number of activities that can contribute to indicator bacteria impairments of surface waters. Activities with the potential to contribute to high indicator bacteria concentrations include:

- Field application of manure,
- Runoff from grazing areas,
- Direct deposition from livestock in streams,
- Animal feeding operations,
- Leaking manure storage facilities, and
- Runoff from barnyards.

Indicator bacteria numbers are generally associated with sediment loading. Reducing sediment loading often results in a reduction of indicator bacteria loading as well. Brief summaries of some of these techniques are provided in the "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*".

Sanitary Waste

Leaking sewer pipes, illicit sewer connections, sanitary sewer overflows (SSOs), combined sewer overflows (CSOs) and failing septic systems represent a direct threat to public health since they result in discharge of partially treated or untreated human wastes to the surrounding environment. Quantifying these sources is extremely speculative without direct monitoring of the source because the magnitude is directly proportional to the volume of the source and its proximity to the surface water. Typical values of fecal coliform in untreated domestic wastewater range from 10^4 to 10^6 MPN/100mL (Metcalf and Eddy 1991).

Illicit sewer connections into storm drains result in direct discharges of sewage via the storm drainage system outfalls. The existence of illicit sewer connections to storm drains is well documented in many urban drainage systems, particularly older systems that may have once been combined. The EPA, MWRA, the Boston Water and Sewer Commission (BWSC) and many communities throughout the Commonwealth have been active in the identification and mitigation of these sources. It is estimated by EPA New England that over one million gallons per day (gpd) of illicit discharges were removed in the last decade in the Charles River Watershed, for example. It is probable that numerous other illicit sewer connections exist in storm drainage systems serving the older developed portions of the Buzzards Bay watershed.

Monitoring of storm drain outfalls during dry weather is needed to document the presence or absence of sewage in the drainage systems. Approximately 29.7 percent of the Buzzards Bay watershed is classified as Urban Areas by the United States Census Bureau and is therefore subject to the Stormwater Phase II Final Rule that requires the development and implementation of an illicit discharge detection and elimination plan. See Section 7.0 of this TMDL for information regarding illicit discharge detection guidance.

Septic systems designed, installed, operated and maintained in accordance with 310 CMR 15.000: Title 5, are not significant sources of fecal coliform bacteria. Studies demonstrate that wastewater located four feet below properly functioning septic systems contain on average less than one fecal coliform bacteria organism per 100 mL (Ayres Associates 1993). Failed or non-conforming septic systems, however, can be a major contributor of fecal coliform to the Buzzards Bay watershed, especially since most of Buzzards Bay's population relies on septic systems versus municipal sewer systems (Appendix A). Wastes from failing septic systems enter surface waters either as direct overland flow or via groundwater. Wet weather events typically increase the rate of transport of pollutant loadings from failing septic systems to surface waters because of the wash-off effect from runoff and the increased rate of groundwater recharge.

Recreational use of waterbodies is a source of pathogen contamination. Swimmers themselves may contribute to bacterial impairment at swimming areas. When swimmers enter the water, residual fecal matter may be washed from the body and contaminate the water with pathogens. In addition, small children in diapers may contribute to contamination of the recreational waters. These sources are likely to be particularly important when the number of swimmers is high and the flushing action of waves or tides is low.

Another potential source of pathogens is the discharge of sewage from vessels with onboard toilets. These vessels are required to have a marine sanitation device (MSD) to either store or treat sewage. When MSDs are operated or maintained incorrectly they have the potential to discharge untreated or inadequately treated sewage. For example, some MSDs are simply tanks designed to hold sewage until it can be pumped out at a shore-based pump-out facility or discharged into the water more than 3 miles from shore. Uneducated boaters may discharge untreated sewage from these devices into near-shore waters. In addition, when MSDs designed to treat sewage are improperly maintained or operated they may malfunction and discharge inadequately treated sewage. Finally, even properly operating MSDs may discharge sewage in concentrations higher than allowed in ambient water for fishing or shellfishing. Vessels are most likely to contribute to bacterial impairment in situations where large numbers of vessels congregate in enclosed environments with low tidal flushing. Many marinas and popular anchorages are located in such environments.

Wildlife and Pet Waste

Animals that are not pets can be a potential source of pathogens. Geese, gulls, and ducks are speculated to be a major pathogen source, particularly at lakes and storm water ponds where large resident populations have become established (Center for Watershed Protection 1999).

Household pets such as cats and dogs can be a substantial source of bacteria – as much as 23,000,000 colonies/gram, according to the Center for Watershed Protection (1999). A rule of thumb estimate for the number of dogs is ~1 dog per 10 people producing an estimated 0.5 pound of feces per dog per day. Using the MADEP's population estimate in 2000, this translates to an estimated 37,369 dogs in the watershed producing 18,685 pounds of feces per day. Uncollected pet waste is then flushed from the parks, beaches and yards where pets are walked and transported into nearby waterways during wet-weather.

Storm Water

Storm water runoff is another significant contributor to pathogen pollution. As discussed above, during rain events fecal matter from domestic animals and wildlife are readily transported to surface waters via the storm water drainage systems and/or overland flow. The natural filtering capacity provided by vegetative cover and soils is dramatically reduced as urbanization occurs because of the increase in impervious areas (i.e., streets, parking lots, etc.) and stream channelization in the watershed.

Extensive storm water data have been collected and compiled both locally and nationally (e.g., Tables 4-1, 4-2, 5-2 and 5-3) in an attempt to characterize the quality of storm water. Bacteria are easily the most variable of storm water pollutants, with concentrations often varying by factors of 10 to 100 during a single storm. Considering this variability, storm water bacteria concentrations are difficult to accurately predict. Caution must be exercised when using values from single wet weather grab samples to estimate the magnitude of bacteria loading because it is often unknown whether the sample is representative of the "true" mean. To gain an understanding of the magnitude of bacterial loading from storm water and avoid overestimating or underestimating bacteria loading, event mean concentrations (EMC) are often used. An EMC is the concentration of a flow proportioned sample throughout a storm event. These samples are commonly collected using an automated sampler which can proportion sample aliquots based on flow. Typical storm water event mean densities for various indicator bacteria in Massachusetts watersheds and nationwide are provided in Tables 5-2 and 5-3. These EMCs illustrate that storm water indicator bacteria concentrations from certain land uses (i.e., residential) are typically at levels sufficient to cause water quality problems.

To obtain a better idea of segments most impacted by storm water and upland areas contributing to storm water, MACZM conducted a survey of the watershed to document storm water discharges (Appendix A). MACZM also noted road cuts in their survey. Impoundments often form upstream of road cuts, which reduce the flow of water. Water accumulates in these impounded areas and can contain elevated fecal coliform levels due to stagnation of the water. Larger impounded areas attract waterfowl thereby increasing the potential for increased bacteria numbers.

Discharge areas were prioritized for remediation in the "*Atlas of Stormwater Discharges in the Buzzards Bay Watershed*" (MACZM 2003), provided in Appendix A of this report. Prioritization of storm water discharge sites is based on several factors including water quality, shellfish resource area classifications, and cost estimates. A complete list and explanation of these criteria can be found in Appendix A of this report and is available for download at http://www.buzzardsbay.org/stormatlas.htm.

Table 5-2. Lower Charles River Basin Storm Water Event Mean Bacteria Concentrations (data summarized from USGS 2002) and Necessary Reductions to Meet Class B WQS.

Land Use Category	Fecal Coliform EMC (CFU/100 mL)	Number of Events	Class B WQS[1]	Reduction to Meet WQS (%)
Single Family Residential	2,800 – 94,000	8	10% of the samples shall not exceed 400 organisms/ 100 mL	2,400 – 93,600 (85.7 – 99.6)
Multifamily Residential	2,200 – 31,000	8		1,800 – 30,600 (81.8 – 98.8)
Commercial	680 – 28,000	8		280 – 27,600 (41.2 - 98.6)

[1] Class B Standard: Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms. Used 400 to illustrate required reductions since a geometric mean of the samples were not provided.

Table 5-3. Storm Water Event Mean Fecal Coliform Concentrations (as reported in MADEP 2002b; original data provided in Metcalf & Eddy, 1992) and Necessary Reductions to Meet Class B WQS.

Land Use Category	Fecal Coliform[1] Organisms / 100 mL	Class B WQS[2]	Reduction to Meet WQS (%)
Single Family Residential	37,000	10% of the samples shall not exceed 400 organisms/ 100 mL	36,600 (98.9)
Multifamily Residential	17,000		16,600 (97.6)
Commercial	16,000		15,600 (97.5)
Industrial	14,000		13,600 (97.1)

[1] Derived from NURP study event mean concentrations and nationwide pollutant buildup data (USEPA 1983).

[2] Class B Standard: Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms. Used 400 to illustrate required reductions since a geometric mean of the samples were not provided.

6.0 Pathogen TMDL Development

Section 303 (d) of the Federal Clean Water Act (CWA) requires states to place water bodies that do not meet the water quality standards on a list of impaired waterbodies. The most recent impairment list, *2002 List*, identifies 30 segments within the Buzzards Bay watershed for use impairment caused by excessive indicator bacteria concentrations.

The CWA requires each state to establish Total Maximum Daily Loads (TMDLs) for listed waters and the pollutant contributing to the impairment(s). TMDLs determine the amount of a pollutant that a waterbody can safely assimilate without violating the water quality standards. Both point and non-point pollution sources are accounted for in a TMDL analysis. Point sources of pollution (those discharges from discrete pipes or conveyances) subject to NPDES permits receive a waste load allocation (WLA) specifying the amount of pollutant each point source can release to the waterbody. Non-point sources of pollution (all sources of pollution other than point) receive a load allocation (LA) specifying the amount of a pollutant that can be released to the waterbody by this source. In accordance with the CWA, a TMDL must account for seasonal variations and a margin of safety, which accounts for any lack of knowledge concerning the relationship between effluent limitations and water quality. Thus:

$$TMDL = WLAs + LAs + Margin\ of\ Safety$$

Where:

WLA = Waste Load Allocation which is the portion of the receiving water's loading capacity that is allocated to each existing and future point source of pollution.

LA = Load Allocation which is the portion of the receiving water's loading capacity that is allocated to each existing and future non-point source of pollution.

This TMDL uses an alternative standards-based approach which is based on indicator bacteria concentrations, but considers the terms of the above equation. This approach is more in line with the way bacterial pollution is regulated (i.e., according to concentration standards) and achieves essentially the same result as if the equation were to be used.

6.1. Indicator Bacteria TMDL

Loading Capacity

The pollutant loading that a waterbody can safely assimilate is expressed as either mass-per-time, toxicity or some other appropriate measure (40 CFR § 130.2). Typically, TMDLs are expressed as total maximum daily loads. Expressing the TMDL in terms of daily loads is difficult to interpret given the very high numbers of indicator bacteria and the magnitude of the allowable load is dependent on flow conditions and, therefore, will vary as flow rates change. For example, a very high load of indicator bacteria are allowable if the volume of water that transports indicator bacteria is also high. Conversely, a relatively low load of indicator bacteria may exceed water quality standard if flow rates are low. Therefore, the MADEP believes it is appropriate to express indicator bacteria TMDLs in

terms of a concentration because the water quality standard is also expressed in terms of the concentration of organisms per 100 mL. Since source concentrations may not be directly added due to varying flow conditions, the TMDL equation is modified and reflects a margin of safety in the case of this pathogen concentration based TMDL. To ensure attainment with Massachusetts' WQS for indicator bacteria, all sources (at their point of discharge to the receiving water) must be equal to or less than the WQS for indicator organisms. For all the above reasons the TMDL is simply set equal to the concentration-based standard and may be expressed as follows:

$$TMDL = State\ Standard = WLA_{(p1)} = LA_{(n1)} = WLA_{(p2)} = etc.$$

Where:

$WLA_{(p1)}$ = allowable concentration for point source category (1)
$LA_{(n1)}$ = allowable concentration for nonpoint source category (1)
$WLA_{(p2)}$ = allowable concentration for point source category (2) etc.

For Class A surface waters (1) *the arithmetic mean of a representative set of fecal coliform samples shall not exceed 20 organisms per 100 mL*; and (2) *no more than 10% of the samples shall exceed 100 organisms per 100 mL.*

For Class B and Class SB and SA areas not designated for shellfishing (1) *the geometric mean of a representative set of fecal coliform samples shall not exceed 200 organisms per 100 mL*; and (2) *no more than 10% of the samples shall exceed 400 organisms per 100 mL*.

For Class SA open shellfish area surface waters (1) *the geometric mean of a representative set of fecal coliform samples shall not exceed 14 organisms per 100 mL*; and (2) *no more than 10% of the samples shall exceed 43 organisms per 100 mL.*

For Class SB open shellfish surface waters (1) *the geometric mean of a representative set of fecal coliform samples shall not exceed 88 organisms per 100 mL*; and (2) *no more than 10% of the samples shall exceed 260 organisms per 100 mL.*

For marine bathing beaches (BEACH Act standard) (1) *the geometric mean of a statistically sufficient number of samples (generally not less than 5 samples equally spaced over a 30-day period) shall not exceed 35 colonies per 100 mL* and (2) *no single enterococci sample shall exceed 104 colonies per 100 mL*.

For freshwater bathing beaches (MADPH standard, not yet adopted by the MADEP) (1) *the geometric mean of the most recent five enterococci levels within the same bathing season shall not exceed 33 colonies per 100 mL* and (2) *no single enterococci sample shall exceed 61 colonies per 100 mL*. – OR – (1) *the geometric mean of the most recent five E. coli levels within the same bathing season shall not exceed 126 colonies per 100 mL* and (2) *no single E. coli sample shall exceed 235 colonies per 100 mL.*

Waste Load Allocations (WLAs) and Load Allocations (LAs)

There are several WWTPs and other NPDES-permitted wastewater discharges within the Buzzards Bay watershed. NPDES wastewater discharge WLAs are set at the WQS. In addition there are numerous storm water discharges from storm drainage systems throughout the watershed. All piped discharges are, by definition, point sources regardless of whether they are currently subject to the requirements of NPDES permits. Therefore, a WLA set equal to the WQS will be assigned to the portion of the storm water that discharges to surface waters via storm drains.

WLAs and LAs are identified for all known source categories including both dry and wet weather sources for Class SA, Class SB, Class A and B segments within the Buzzards Bay watershed. Establishing WLAs and LAs that only address dry weather indicator bacteria sources would not ensure attainment of standards because of the significant contribution of wet weather indicator bacteria sources to WQS exceedances. Illicit sewer connections and deteriorating sewers leaking to storm drainage systems represent the primary dry weather point sources of indicator bacteria, while failing septic systems and possibly leaking sewer lines represent the non-point sources. Wet weather point sources include discharges from storm water drainage systems (including MS4s), sanitary sewer overflows (SSOs) and combined sewer overflows (CSOs). Wet weather non-point sources primarily include diffuse storm water runoff.

Table 6-1 presents the indicator bacteria WLAs and LAs for the various source categories. WLAs and LAs will change to reflect the revised indicator organisms (*E. coli* and enterococci) when the updated WQS have been finalized (See Section 3.0 of this report). Source categories representing discharges of untreated sanitary sewage to receiving waters are prohibited, and therefore, assigned WLAs and LAs equal to zero. There are several sets of WLAs and LAs, one for Class SA shellfish open waters, one for Class SB shellfish open waters, one for Class A waters, one for Class B and shellfish restricted Class SA and SB waters, one for no discharge areas, one for freshwater beaches, and one for marine beaches.

The TMDL should provide a discussion of the magnitudes of the pollutant reductions needed to attain the goals of the TMDL. Since accurate estimates of existing sources are generally unavailable, it is difficult to estimate the pollutant reductions for specific sources. For the illicit sources including failing septic systems, the goal is complete elimination (100% reduction). However, overall wet weather indicator bacteria load reductions can be estimated using typical storm water bacteria concentrations, as presented in the *Buzzards Bay Watershed 2000 Water Quality Assessment Report* and the *Atlas of Stormwater Discharges in the Buzzards Bay Watershed*. These data indicate that up to two to three orders of magnitude (i.e., greater than 90%) reductions in storm water fecal coliform loadings generally will be necessary, especially in developed areas. This goal is expected to be accomplished through implementation of the best management practices (BMPs) associated with the Phase II control program in designated Urban Areas. The specific goal for controlling discharges from combined sewer overflows (CSOs) will be based on the site specific studies embodied in the Long Term Control Plan being developed by each community with combined sewers.

Table 6-1. Indicator Bacteria Waste Load Allocations (WLAs) and Load Allocations (LAs) for the Buzzards Bay Watershed.

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)[1]	Load Allocation Indicator Bacteria (CFU/100 mL)[1]
A, B, SA, SB	Illicit discharges to storm drains	0	N/A
A, B, SA, SB	Leaking sanitary sewer lines	0	N/A
A, B, SA, SB	Failing septic systems	N/A	0
A	NPDES – WWTP	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples, nor shall 10% of the samples exceed 100 organisms[2]	N/A
A	Storm water runoff Phase I and II	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples nor shall 10% of the samples exceed 100 organisms[3]	N/A
A	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples, nor shall 10% of the samples exceed 100 organisms[3]
B & Not Designated for Shellfishing SA & SB	CSOs	Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[4]	N/A
B & Not Designated for Shellfishing SA & SB	NPDES – WWTP	Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[2]	N/A
B & Not Designated for Shellfishing SA & SB	Storm water runoff Phase I and II	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[3]	N/A
B & Not Designated for Shellfishing SA & SB	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[3]

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)[1]	Load Allocation Indicator Bacteria (CFU/100 mL)[1]
SA Designated Shellfishing Areas	NPDES – WWTP	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms[2]	N/A
SA Designated Shellfishing Areas	Storm water Runoff Phase I and II	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms[3]	N/A
SA Designated Shellfishing Areas	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms[3]
SB Designated Shellfishing Areas	CSOs	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms[4]	N/A
SB Designated Shellfishing Areas	NPDES – WWTP	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms[2]	N/A
SB Designated Shellfishing Areas	Storm water runoff Phase I and II	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms[3]	N/A
SB Designated Shellfishing Areas	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms[3]
No Discharge Areas	Vessels – raw or treated sanitary waste	0	N/A
Marine Beaches[5]	All Sources	Enterococci not to exceed a geometric mean of 35 colonies in a statistically significant number of samples, nor shall any single sample exceed 104 colonies	Enterococci not to exceed a geometric mean of 35 colonies in a statistically significant number of samples, nor shall any single sample exceed 104 colonies

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)[1]	Load Allocation Indicator Bacteria (CFU/100 mL)[1]
Fresh Water Beaches[6]	All Sources	Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies OR *E. coli* not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies	Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies OR *E. coli* not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies

N/A means not applicable

[1] Waste Load Allocation (WLA) and Load Allocation (LA) refer to fecal coliform densities unless specified in table.

[2] Or shall be consistent with the Waste Water Treatment Plant (WWTP) National Pollutant Discharge Elimination System (NPDES) permit.

[3]The expectation for WLAs and LAs for storm water discharges is that they will be achieved through the implementation of BMPs and other controls.

[4] Or shall be consistent with an approved Long Term Control Plan (LTCP) for Combined Sewer Overflow (CSO) abatement. If the level of control specified in the LTCP is less than what is necessary to attain Class B water quality standards, then the above criteria apply unless MADEP has proposed and EPA has approved water quality standards revisions for the receiving water.

[5] Federal Beaches Environmental Assessment and Coastal Health Act of 2000 (BEACH Act) Water Quality Criteria.

[6] Massachusetts Department of Public Health regulations (105 CMR Section 445).

Note: this table represents waste load and load reductions based on water quality standards current as of the publication date of these TMDLs, any future changes made to the Massachusetts water quality standards will become the governing water quality standards for these TMDLs.

The expectation to attain WQS at the point of discharge is environmentally protective, and offers a practical means to identify and evaluate the effectiveness of control measures. In addition, this approach establishes clear objectives that can be easily understood by the public and individuals responsible for monitoring activities.

This TMDL applies to the 30 pathogen impaired segments of the Buzzards Bay watershed that are currently listed on the CWA § 303(d) list of impaired waters. MADEP recommends however, that the information contained in this TMDL guide management activities for all other waters throughout the watershed to help maintain and protect existing water quality. For these non-impaired waters, Massachusetts is proposing "pollution prevention TMDLs" consistent with CWA § 303(d)(3).

The analyses conducted for the pathogen impaired segments in this TMDL would apply to the non-impaired segments, since the sources and their characteristics are equivalent. The waste load and/or load allocation for each source and designated use would be the same as specified herein. Therefore, the pollution prevention TMDLs would have identical waste load and load allocations based on the sources present and the designated use of the water body segment (see Table ES-1 and Table 6-1).

This Buzzards Bay watershed TMDL may, in appropriate circumstances, also apply to segments that are listed for pathogen impairment in subsequent Massachusetts CWA § 303(d) Integrated List of Waters. For such segments, this TMDL may apply if, after listing the waters for pathogen impairment and taking into account all relevant comments submitted on the CWA § 303(d) list, the Commonwealth determines with EPA approval of the CWA § 303(d) list that this TMDL should apply to future pathogen impaired segments.

6.2. Margin of Safety

This section addresses the incorporation of a Margin of Safety (MOS) in the TMDL analysis. The MOS accounts for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality. The MOS can either be implicit (i.e., incorporated into the TMDL analysis through conservative assumptions) or explicit (i.e., expressed in the TMDL as a portion of the loadings). This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Realistically, influent water will mix with the receiving water and become diluted below the water quality standard, provided that the receiving water concentration does not exceed the TMDL concentration. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur.

6.3. Seasonal Variability

In addition to a Margin of Safety, TMDLs must also account for seasonal variability. Pathogen sources to Buzzards Bay waters arise from a mixture of continuous and wet-weather driven sources, and there may be no single critical condition that is protective for all other conditions. This TMDL has set WLAs and LAs for all known and suspected source categories equal to the Massachusetts WQS independent of seasonal and climatic conditions. This will ensure the attainment of water quality standards regardless of seasonal and climatic conditions. Controls that are necessary will be

in place throughout the year, protecting water quality at all times. However, for discharges that do not affect shellfish beds, intakes for water supplies and primary contact recreation is not taking place (i.e., during the winter months) seasonal disinfection is permitted for NPDES point source discharges.

7.0 Implementation Plan

Setting and achieving TMDLs should be an iterative process with realistic goals over a reasonable timeframe and adjusted as warranted based on ongoing monitoring. The concentrations set out in the TMDL represent reductions that will require substantial time and financial commitment to be attained. A comprehensive control strategy is needed to address the numerous and diverse sources of pathogens in the Buzzards Bay watershed.

Controls on several types of pathogen sources will be required as part of the comprehensive control strategy. Many of the sources in the Buzzard Bay Watershed including sewer connections to drainage systems, leaking sewer pipes, sanitary sewer overflows, and failing septic systems, are prohibited and must be eliminated. Individual sources must be first identified in the field before they can be abated. Pinpointing sources typically requires extensive monitoring of the receiving waters and tributary storm water drainage systems during both dry and wet weather conditions. A comprehensive program is needed to ensure illicit sources are identified and that appropriate actions will be taken to eliminate them. The MADEP, MACZM, EPA, Buzzards Bay Action Committee (BBAC) and the Coalition for Buzzards Bay (CBB) have been successful in carrying out such monitoring, identifying sources, and, in some cases, mobilizing the responsible municipality and other entities to begin to take corrective actions.

The City of New Bedford Department of Public Works Waste Water Division has been addressing CSOs since 1989 (City of New Bedford 2005). There are currently 35 CSO outfalls discharging into Clarks Cove, New Bedford Harbor and Buzzards Bay. As a result of their efforts, two shellfish beds, which have been closed for 30 years, have been reopened (City of New Bedford 2005). Work toward mitigating CSO impacts is ongoing and part of the City of New Bedford's long term CSO control plan (New Bedford CSO Facilities Plan).

Storm water runoff represents another major source of pathogens in the Buzzards Bay watershed, and the current level of control is inadequate for standards to be attained. Improving storm water runoff quality is essential for restoring water quality and recreational uses. At a minimum, intensive application of non-structural BMPs is needed throughout the watershed to reduce pathogen loadings as well as loadings of other storm water pollutants (e.g., nutrients and sediments) contributing to use impairment in the Buzzards Bay watershed. Depending on the degree of success of the non-structural storm water BMP program, structural controls may become necessary.

For these reasons, a basin-wide implementation strategy is recommended. The strategy includes a mandatory program for implementing storm water BMPs and eliminating illicit sources. The "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*" was developed to support implementation of pathogen TMDLs. TMDL implementation-related tasks are shown in Table 7-1. The MADEP working with EPA and other team partners shall make every reasonable effort to assure implementation of this TMDL. These stakeholders can provide valuable assistance in defining hot spots and sources of pathogen contamination as well as the implementation of mitigation or preventative measures.

Table 7-1. Tasks

Task	Organization
Writing TMDL	MADEP
TMDL public meeting	MADEP
Response to public comment	MADEP
Organization, contacts with volunteer groups	MADEP/CBB
Development of comprehensive storm water management programs including identification and implementation of BMPs	Buzzards Bay Communities
Illicit discharge detection and elimination	Buzzards Bay Communities with CBB
Leaking sewer pipes and sanitary sewer overflows	Buzzards Bay Communities
CSO management	City of New Bedford
Inspection and upgrade of on-site sewage disposal systems as needed	Homeowners and Buzzards Bay Communities (Boards of Health)
Organize and implement; work with stakeholders and local officials to identify remedial measures and potential funding sources	MADEP, CBB and Buzzards Bay Communities
Organize and implement education and outreach program	MADEP, CBB and Buzzards Bay Communities
Write grant and loan funding proposals	CBB, Buzzards Bay Communities and Planning Agencies with guidance from MADEP
Inclusion of TMDL recommendations in Executive Office of Environmental Affairs (EOEA) Watershed Action Plan	EOEA
Surface Water Monitoring	MADEP and CBB
Provide periodic status reports on implementation of remedial activities	EOEA, CBB

7.1. Summary of Activities within the Buzzards Bay Watershed

There are two not-for-profit active stewards of the Buzzards Bay, the Coalition for Buzzards Bay (CBB) and the Buzzards Bay Action Committee (BBAC). The CBB is a citizens group primarily focused on education and outreach and the BBAC, consisting of municipal officials, focusing on regulation and legislation issues. These organizations, with assistance from the EPA and MACZM, have developed the Buzzards Bay Project National Estuary Program where their mission is "To protect and restore water quality and living resources in Buzzards Bay and its surrounding watershed through the implementation of the Buzzards Bay Comprehensive Conservation and Management Plan" (CCMP; available for download at http://www.buzzardsbay.org/ccmptoc.htm). The CCMP includes the following action plans:

- Managing Nitrogen-Sensitive Embayments
- Protecting and Enhancing Shellfish Resources
- Controlling Stormwater Runoff
- Managing Sanitary Wastes from Boats
- Managing On-Site Systems
- Preventing Oil Pollution
- Protecting Wetlands and Coastal Habitat
- Planning for a Shifting Shoreline
- Managing Sewage Treatment Facilities
- Reducing Toxic Pollution
- Managing Dredging and Dredged Material Disposal

The first effort in controlling storm water runoff featured a storm water mapping task. This effort resulted in the publication of the "*Atlas of Stormwater Discharges in the Buzzards Bay Watershed*"(provided in Appendix A). Storm water mapping is continuing in areas not included in the original effort. Data collected during the mapping process is used to set remediation implementation priorities within the watershed. The BBAC works closely with municipalities in an effort to improve conditions within the bay. A list of on-going and past projects is provided on the following web-site http://www.buzzardsbay.org/.

Data supporting this TMDL indicate that indicator bacteria enter the Buzzards Bay from a number of contributing sources, under a variety of conditions. Activities that are currently ongoing and/or planned to ensure that the TMDL can be implemented include and are summarized in the following subsections. The "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*" provides additional details on the implementation of pathogen control measures summarized below as well as additional measures not provided herein, such as by-law, ordinances and public outreach and education.

7.2. Agricultural Runoff – Animal Feeding Operations and Grazing

Animal feeding operations and barnyards can produce significant volumes of manure with high fecal loads. To reduce the impacts of animal feeding operations, EPA recommends addressing the following eight issues (USEPA 2003).

1. *Divert clean water* - divert clean water (run-off from uplands, water from roofs) from contact with feedlots and holding pens, animal manure, or manure storage systems.
2. *Prevent seepage.*
3. *Provide adequate storage*.
4. *Apply manure in accordance with a nutrient management plan that meets the performance expectations of the nutrient management measure.*
5. *Address lands receiving wastes*. Areas receiving manure should be managed in accordance with the erosion and sediment control, irrigation, and grazing management measures as applicable.
6. *Recordkeeping.* Operators should keep records that indicate the quantity of manure produced and its utilization or disposal method, including land application.
7. *Mortality management*. Dead animals should be managed in a way that does not adversely affect ground or surface waters.
8. *Consider the full range of environmental constraints and requirements.* When siting a new or expanding facility, consideration should be given to the proximity of the facility to (a) surface waters; (b) areas of high leaching potential; (c) areas of shallow groundwater; and (d) sink holes or other sensitive areas.

Grazing best management practices can reduce erosion, the concentrations of bacteria in runoff from grazing areas, and the direct deposition of fecal matter into water bodies. The following grazing management practices may be implemented at agricultural sites as part of the overall implementation strategy to reduce pathogen discharges to receiving waters.

- Exclude livestock from surface water bodies, and sensitive shoreline and riparian zones,
- Provide bridges or culverts for stream crossings,
- Provide alternative drinking water locations,
- Locate salt, feeding areas, and additional shade away from sensitive areas, and
- Use improved grazing management to reduce erosion and overgrazing.

Additional details and a list of useful resources regarding animal feeding operations and grazing management is provided in the "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*".

7.3. Illicit Sewer Connections, Failing Infrastructure and CSOs

Elimination of illicit sewer connections, repairing failing infrastructure, and controlling impacts associated with CSOs are of extreme importance. In 1990, the New Bedford CSO Facilities Plan was completed. The City is currently in the process of reassessing the plan, but the originally projected $191 million implementation cost will likely constrain the plan's full implementation.

Guidance for illicit discharge detection and elimination has been developed by EPA New England (USEPA 2004c) for the Lower Charles River. The guidance document provides a plan, available to all Commonwealth communities, to identify and eliminate illicit discharges (both dry and wet weather) to their separate storm sewer systems. Although originally prepared for the Charles River

Watershed it is applicable to all watersheds throughout the Commonwealth. Implementation of the protocol outlined in the guidance document satisfies the Illicit Discharge Detection and Elimination requirement of the NPDES program. A copy of the guidance document is provided in Appendix B.

7.4. Storm Water Runoff

Storm water runoff can be categorized in two forms; 1) point source discharges and 2) non-point source discharges (includes sheet flow or direct runoff). Many point source storm water discharges are regulated under the NPDES Phase I and Phase II permitting programs when discharged to a Waters of the United States. Municipalities that operate regulated municipal separate storm sewer systems (MS4s) must develop and implement a storm water management plan (SWMP), which must employ and set measurable goals for the following six minimum control measures:

1. public education and outreach particularly on the proper disposal of pet waste,
2. public participation/involvement,
3. illicit discharge detection and elimination,
4. construction site runoff control,
5. post construction runoff control, and
6. pollution prevention/good housekeeping.

Portions of towns in this watershed are classified as Urban Areas by the United States Census Bureau and are subject to the Stormwater Phase II Final Rule. This rule requires the development and implementation of an illicit discharge detection and elimination plan.

The BBAC created a web page to help municipalities with obtaining their Phase II permits. Partly due to their efforts, 95% of the municipalities submitted their permit applications within the required time limit (all municipalities have submitted their permit application at this point)

The NPDES permit does not, however, establish numeric effluent limitations for storm water discharges. Maximum extent practicable (MEP) is the statutory standard that establishes the level of pollutant reductions that regulated municipalities must achieve. The MEP standard is a narrative effluent limitation that is satisfied through implementation of SWMPs and achievement of measurable goals.

Non-point source discharges are generally characterized as sheetflow runoff and are not categorically regulated under the NPDES program and can be difficult to manage. However, some of the same principles for mitigating point source impacts may be applicable. Individual municipalities not regulated under the Phase I or II should implement the exact same six minimum control measures minimizing storm water contamination.

7.5. Failing Septic Systems

Figure 16 in Appendix A demonstrates the small portion of the Buzzards Bay basin serviced by municipal sanitary sewer systems. Because of this, much of the Buzzards Bay basin relies on on-site waste water systems such as septic systems. Septic system bacteria contributions to the Buzzards Bay watershed may be reduced in the future through septic system maintenance and/or replacement. Additionally, the implementation of Title 5, which requires inspection of private sewage

disposal systems before property ownership may be transferred, building expansions, or changes in use of properties, will aid in the discovery of poorly operating or failing systems. Because systems which fail must be repaired or upgraded, it is expected that the bacteria load from septic systems will be significantly reduced in the future. Regulatory and educational materials for septic system installation, maintenance and alternative technologies are provided by the MADEP on the worldwide web at http://www.mass.gov/dep/brp/wwm/t5pubs.htm.

7.6. Wastewater Treatment Plants

WWTP discharges are regulated under the NPDES program when the effluent is released to surface waters. Each WWTP has an effluent limit included in its NPDES or groundwater permit. Some NPDES permits are listed on the following website: www.epa.gov/region1/npdes/permits_listing_ma.html. Groundwater permits are available at http://www.mass.gov/dep/brp/gw/gwhome.htm.

7.7. Recreational Waters Use Management

Recreational waters receive pathogen inputs from swimmers and boats. To reduce swimmers' contribution to pathogen impairment, shower facilities can be made available, and bathers should be encouraged to shower prior to swimming. In addition, parents should check and change young children's diapers when they are dirty. Options for controlling pathogen contamination from boats include:

- petitioning the State for the designation of a No Discharge Area (NDA),
- supporting installation of pump-out facilities for boat sewage,
- educating boat owners on the proper operation and maintenance of marine sanitation devices (MSDs), and
- encouraging marina owners to provide clean and safe onshore restrooms and pump-out facilities.

The entire Buzzards Bay has already been established as a no discharge area (NDA). This area was designated by the Commonwealth of Massachusetts and approved by the EPA to provide protection by Federal Law prohibiting the release of raw or treated sewage from vessels into navigable waters of the U.S. The law is enforced by the Massachusetts Environmental Police. The MACZM and Massachusetts Environmental Law Enforcement are actively pursuing an amendment to State regulations allowing for the institution of fines up to $2000 for violations within a NDA (USEPA 2004a).

7.8. Funding/Community Resources

A complete list of funding sources for implementation of non-point source pollution is provided in Section VII of the Massachusetts Nonpoint Source Management Plan Volume I (MADEP 2000b) available on line at http://www.mass.gov/dep/brp/wm/nonpoint.htm. This list includes specific programs available for non-point source management and resources available for communities to manage local growth and development. The State Revolving Fund (SRF) provides low interest loans to communities for certain capital costs associated with building or improving wastewater treatment facilities. In addition, many communities in Massachusetts sponsor low cost loans through the SRF for homeowners to repair or upgrade failing septic systems.

7.9. Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts

For a more complete discussion on ways to mitigate pathogen water pollution, see the "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*" accompanying this document.

8.0 Monitoring Plan

The long term monitoring plan for the Buzzards Bay watershed includes several components:

1. continue with the current monitoring of the Buzzards Bay watershed (CBB, DMF and other stakeholders),
2. continue with MADEP watershed five-year cycle monitoring,
3. monitor areas within the watershed where data are lacking or absent to determine if the waterbody meets the use criteria,
4. monitor areas where BMPs and other control strategies have been implemented, or discharges have been removed, to assess the effectiveness of the modification or elimination,
5. assemble data collected by each monitoring entity to formulate a concise report where the basin is assessed as a whole and an evaluation of BMPs can be made, and
6. add/remove/modify BMPs as needed based on monitoring results.

The monitoring plan is an ever changing document that requires flexibility to add, change or delete sampling locations, sampling frequency, methods and analysis. At the minimum, all monitoring should be conducted with a focus on:

- capturing water quality conditions under varied weather conditions,
- establishing sampling locations in an effort to pin-point sources,
- researching new and proven technologies for separating human from animal bacteria sources, and
- assessing efficacy of BMPs.

9.0 Reasonable Assurances

Reasonable assurances that the TMDL will be implemented include both enforcement of current regulations, availability of financial incentives including low or no-interest loans to communities for wastewater treatment facilities through the State Revolving Fund (SRF), and the various local, state and federal programs for pollution control. Storm water NPDES permit coverage will address discharges from municipal owned storm water drainage systems. Enforcement of regulations controlling non-point discharges includes local enforcement of the states Wetlands Protection Act and Rivers Protection Act; Title 5 regulations for septic systems and various local regulations including zoning regulations. Financial incentives include Federal monies available under the CWA Section 319 NPS program and the CWA Section 604 and 104b programs, which are provided as part of the Performance Partnership Agreement between MADEP and the EPA. Additional financial incentives include state income tax credits for Title 5 upgrades, and low interest loans for Title 5 septic system upgrades through municipalities participating in this portion of the state revolving fund program.

10.0 Public Participation

To be added later….

11.0 References

Ayres Associates 1993. Onsite Sewage Disposal Systems Research in Florida. The Capacity of Fine Sandy Soil for Septic Tank Effluent Treatment: A Field Investigation at an In-Situ Lysimeter Facility in Florida.

BBPNEP 2002. Chapter 6: Pollution Remediation Projects in New Bedford. Buzzards Bay Project National Estuary Program (BBPNEP). Available for download at http://www.buzzardsbay.org/nbprobs.htm.

Center for Watershed Protection, 1999. Watershed Protection Techniques. Vol. 3, No. 1.

City of New Bedford 2005. City of New Bedford Department of Public Works Waste Water Division. Information from website, downloaded March 2005. http://www.ci.new-bedford.ma.us/DPW/WASTEWAT/combins.htm

DMF 2002. Massachusetts Division of Marine Fisheries. Programs and Projects. Shellfish Sanitation and Management. Information from website, downloaded March 2005. http://www.mass.gov/dfwele/dmf/programsandprojects/shelsani.htm

MACZM. 2003. Atlas of Stormwater Discharges in the Buzzards Bay Watershed, August 2003. Massachusetts Office of Coastal Zone Management (MACZM), Buzzards Bay Project National Estuaries Program. East Wareham, Massachusetts. Available for download at http://www.buzzardsbay.org/stormatlas.htm

MADEP 2000a. 314 CMR 4.00: Massachusetts Surface Water Quality Standards. Massachusetts Department of Environmental Protection Bureau of Waste Prevention. Available for download at http://www.mass.gov/dep/bwp/iww/files/314cmr4.htm

MADEP 2000b. Nonpoint Source Management Plan Volume I Strategic Summary. Massachusetts Department of Environmental Protection Bureau of Waste Prevention. Available for download at http://www.mass.gov/dep/brp/wm/nonpoint.htm

MADEP 2002a. Cape Cod Watershed Water Quality Assessment Report. Massachusetts Department of Environmental Protection, Division of Water Management. Worcester, Massachusetts. Available for download at http://www.mass.gov/dep/brp/wm/wqassess.htm

MADEP 2002b. Final Total Maximum Daily Loads of Bacteria for Neponset River Basin. Massachusetts Department of Environmental Protection, Bureau of Resource Protection, Division of Watershed Management. Report MA73-01-2002 CN 121.0. Boston, Massachusetts. Available for download at http://www.mass.gov/dep/brp/wm/tmdls.htm.

MADEP 2003a. Massachusetts Year 2002 Integrated List of Waters. Part 2 – Final Listing of Individual Categories of Waters. Massachusetts Department of Environmental Protection, Bureau of Resource Protection, Division of Watershed Management. Boston, Massachusetts. Available for download at http://www.mass.gov/dep/brp/wm/tmdls.htm

MADEP 2003b. Buzzards Bay Watershed 2000 Water Quality Assessment Report. Massachusetts Department of Environmental Protection, Division of Water Management. Worcester, Massachusetts. Available for download at http://www.mass.gov/dep/brp/wm/wqassess.htm

MassGIS 2005. Office of Geographic and Environmental Information (MassGIS), Commonwealth of Massachusetts Executive Office of Environmental Affairs. MADEP 2002 Integrated List of Waters (305(b)/303(d)) as of 2005; Land Use as of 1999; Town Boundaries as of 2002. Census TIGER Roads as of 2003. Major Drainage Boundaries as of 2003. Designated Shellfish Growing Areas as of July 2000. Downloaded January 2005. http://www.mass.gov/mgis/laylist.htm

MDC-CDM. 1997. Wachusett Stormwater Study. Massachusetts District Commission and Camp, Dresser, and McKee, Inc.

Metcalf and Eddy 1991. Wastewater Engineering: Treatment, Disposal, Reuse. Third Edition.

Metcalf and Eddy 1992. Casco Bay Storm Water Management Project.

USEPA 1983. Results of the Nationwide Urban Runoff Program. Volume I. Final Report. Water Planning Division. Washington, D.C. 159 pp.

USEPA 1986. Ambient Water Quality Criteria for Bacteria – 1986. EPA 440/5-84-002.

USEPA. 1997. Urbanization of Streams: Studies of Hydrologic Impacts. EPA 841-R-97-009

USEPA 1999. Regional Guidance on Submittal Requirements for Lake and Reservoir Nutrient TMDLs. USEPA, New England Region. November 1999.

USEPA 2001. Protocol for Developing Pathogen TMDLs. EPA 841-R-00-002

USEPA 2003. National Management Measures to control Nonpoint Source Pollution from Agriculture. EPA 841-B-03-004. Available at: http://www.epa.gov/owow/nps/agmm/index.html

USEPA 2004a. No Discharge Areas in Massachusetts. Information from website, downloaded March 2005. http://www.epa.gov/region01/eco/nodiscrg/ma.html

USEPA 2004b. Monitoring and Assessing Water Quality. Information from website, downloaded December 2004. http://www.epa.gov/OWOW/monitoring/volunteer/stream/vms511.html

USEPA 2004c. Lower Charles River Illicit Discharge Detection & Elimination (IDDE) Protocol Guidance for Consideration - November 2004 United States Environmental Protection Agency Region I New England

USGS 2002. Measured and Simulated Runoff to the Lower Charles River, Massachusetts, October 199-September 2000. 02-4129. United States Geological Survey. Northborough, Massachusetts.

Appendix A

Atlas of Stormwater Discharges in the Buzzards Bay Watershed (MACZM 2003)

Also available for download at http://www.buzzardsbay.org/stormatlas.htm

Appendix B

Lower Charles River Illicit Discharge Detection & Elimination (IDDE)
Protocol Guidance for Consideration - November 2004